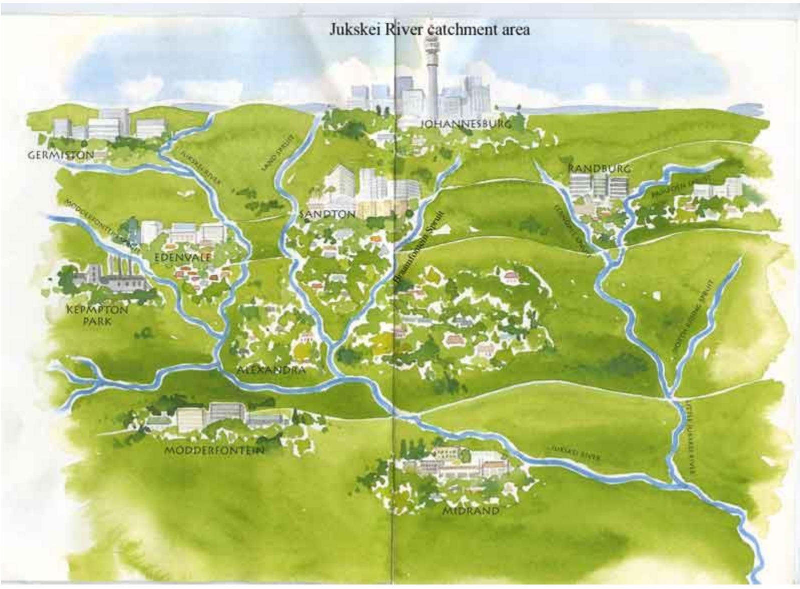
GEOGRAPHY RESEARCH ASSIGNMENT 2012

As pollution increases in a river system, so will the indigenous plant life decrease in occurrence and alien life to the area will begin to propagate due to the pollution.

7/17/2012
Jason Chalom



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Contents

Acknowledgements *3*

Introduction *4*

Background 4

Problem Statement 4

Scale of the study 4

Aim and Objectives 4

Review of Literature *6*

The effects of Nitrates in water. 6

What is eutrophication 6

The known pollution in the Jukskei River network and its effects 6

Efforts to help alleviate the pollution 7

Method *8*

Field Protocol for Geography Field Assignment 8

Water Sample Processing Using Sera Quick Test Water Testing Strips 9

Processing of Findings *10*

Conclusion *12*

Appendix A *13*

Location of Study and Satellite Image from Google Earth 13

Map of whole study 13

Satellite Image of Sites 1 and 2 14

Satellite image of sites 3, 4 and 5 15

Appendix B *16*

Primary Data Collected from River on 12/04/2012, plant samples, water samples and soil samples 16

Site 1 – Beez Valley 16

Site 2 – Bruma Lake 19

Site 3 – Sandspruit tributary Edenvale 21

Site 4 - Lyndhurst 23

Site 5 –Alexandra Outflow 26

Appendix C *29*

Sources from Local Media 29

Part 1: Toxic Threat Under Your Feet 29

Part 2: Proposal for Bruma Lake Welcomed 31

Part 3: Construction of Litter Traps Underway 32

Literature pertaining to the Jukskei River **33**
Part 1: Data from Wadzanai Matowanyika's research report........ 33
Part 2: Extract from: Diatoms as indicators of water quality in the Jukskei-Crocodile river system in 1956 and 1957, a re-analysis of diatom count data generated by BJ Cholnoky........ 38
Literature pertaining to the Effect of Nitrates in Water **39**
Nitrates in the Aquarium........ 39
Appendix D ***41***
Water Quality Tests from Different Sources, Including graphs created for this project from the raw data **41**
My Own Collected Data 41
Raw Data That I Collected From Water Samples........ 41
Interview with The Department Of Environmental Affairs **42**
Appendix E ***44***
Graphs **44**
RAW Data and Locations of Municipal Test Sites **50**
Satellite Images of Municipal Test Sites **51**
Water Table Index Used by CoJ **52**

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Introduction

Background

The Jukskei River is known to have a serious pollution problem (see appendix C), and it has been speculated about what effects this pollution is having on the local ecology and people residing in the area. I live near the Jukskei River and so I have a personal concern with the effect of the river on my environment – This is the reason I decided to conduct a geography research assignment on the effects pollution causes to river systems and their ecology.

Problem Statement

I have conducted research to determine the impact of pollution on flora and fauna living around the Jukskei River System. The investigation that I conducted was to prove that the hypothesis: As the pollution in a river increases (i.e. downstream or over the years), so will the health of the indigenous life living off the river decrease and new alien life will begin to form in the area.

South Africa faces a major problem of high density population clustered in townships and the inner cities. The Jukskei River flows from a high density, built up area, through lower density residential area and then through Alexandra Township which is extremely high density. As the population in South Africa has grown, especially in Johannesburg the amount of water pollution has increased. This pollution increase has been directly seen within the Jukskei River System, where people constantly complain about the smell and sight of it. There have also been cases of health related issues. (See Appendix C, part 1 and 2)This increase in pollution poses a considerable threat to health of the people living in the area and the environment around this now polluted river system. This pollution in the river should have a visible and direct impact on the flora and fauna in the area which would indicate how badly and damaging this pollution is – and therefore how severe the problem is.

Scale of the study

The scale of the study is in a fairly small contained area. The study goes from Beez Valley downstream until the exit of the Jukskei from Alexandra Township. The study takes place at five different test sites located along the Jukskei. Site 3 however is on the Sandspruit which flows into the Jukskei. This is here to give an idea of how an area which may have less pollution with similar ecology compares to the main flow of the Jukskei to give an idea to the extent of the pollution along the Jukskei River. (See Appendix A for Satellite Images of my different testing sites.)

Aim and Objectives

Water pollution is hard to quantify. There are many different aspects to it such as Nitrates/Nitrites, phosphates, sulphates, oxygen levels, bacterial levels, Diatoms, Ammonia amounts, conductivity, pH and turbidity of the water. These factors relate differently to different flora and fauna in the area. For instance different bacteria can positively or negatively affect the pH levels and therefore change the expected results from the water tests. Temperature and time of the year also matters. When agriculture is at the point in summer when lots of fertilizer is used this will affect the type of pollution in the river. Animals also migrate at different times of the year and are therefore hard to quantify in a short period of time how much fauna there is in a particular area. There is also indigenous life which is strong against pollution and so will not be affected by it as expected to be.

I have conducted a field survey where I went out in the field to five different sites. I collected water samples, plant samples and conducted experiments in the field. I also have had two interviews with different surveyors in The Department of Environmental Affairs regarding the Jukskei River Catchment Area. There have been other studies and projects done on the pollution in the Jukskei River and its effect. I have included a few examples. I have also looked at local media which many articles have been published on the problem of pollution in the Jukskei River and what has been done to alleviate it.

I want to see how the pollution in the Jukskei River has affected the ecology in the area and I have attempted to find these effects from the data which I have collected on the Jukskei River.

Review of Literature

The effects of Nitrates in water.

Nitrates are needed by riverine plants to survive. (See Appendix C, Literature pertaining to the Effect of Nitrates in Water) In high enough levels though, it causes unwanted growth of algae and leads to eutrophication. The plant life is not able to use enough Nitrates, fast enough thereby increasing the amount of nitrates present in the water and if the levels of Nitrates are high enough the algal growth will become so high that it will 'choke' and kill off the plant life due to competition of limited resources found in the ecosystem. Nitrates affect the ability of fish to reproduce and grow to full maturity. It also greatly weakens their resistance to disease and the fish exposed to high levels of Nitrates will begin to reduce in number, health and size. This high Nitrate level is due to urbanisation in Johannesburg, the poor conditions of Hartbeespoort dam which itself experiences high eutrophication and the poor conditions experienced in the township, Alexandra which greatly adds to the already polluted water. (See appendix C, Literature pertaining to the Jukskei, part 1)

What is eutrophication

Eutrophication is when a water source has a high quantity of nutrients which causes an undesired algae bloom. This causes a deterioration of water quality and hinders or negatively affects water uses and the sustainability of life within the river system. (see appendix C, Literature pertaining to the Jukskei, part 2).

The known pollution in the Jukskei River network and its effects

There are many different contributing factors to the pollution in the Jukskei River. A very frightful and recently found pollutant of the Jukskei River is acid mine drainage. This contaminated water from abandoned mines found in and around Johannesburg has begun to seep into the water basin and in turn into the Jukskei River System. (See Appendix C, Sources from local media, part 1) This water is extremely acidic and even contains other dangerous pollutants like uranium and heavy metals. This toxic pollution is said to turn soil barren and destroy aquatic life.

Another form of pollution comes from the fact that the Jukskei River and all the manmade dams and reservoirs connected to it were designed for through flow a storm water drainage in mind. (See Appendix C, Sources from local media, part 4) The reason for this was because these systems were built to get rid of storm water runoff from the city and suburbs. This water is polluted and therefore contaminates the river with all kinds of pollutants such as high levels of nitrates. There is also faecal pollution in the river which also contributes to the high amount of nitrates in the water as well as the high bacterial count. This bad design has led to the river having high amounts of erosion and therefore these dams and reservoirs are becoming filled with sediment which contains these pollutants, reducing the water quality even more by saturating the water with these pollutants rather than being able to transport them downstream. These pollutants promote algal blooms which kill off the natural aquatic life in the area which in turn reduce the biodiversity found here. Another effect of this pollution is that recreational zones which have the river flowing through them have been negatively affected due to the smell and other associated problems caused by the pollution in the water. These zones are in danger of becoming unusable due to the high pollution.

There is a major input of pollution into the river from an increase in urbanisation and population density. (See appendix C, Literature pertaining to the Jukskei, part 1) Alexandra is a township which since the 80's has seen a major growth in population density. This township did not have adequate infrastructure to deal with the increase in population such as the removal of garbage and adequate sewerage facilities for the populous. There have been subsequent developments in the infrastructure in the area but this has increased the amount of urbanisation taking place which means these systems are continuously strained. This leads to sewerage and garbage being dumped into the river system.

Efforts to help alleviate the pollution

There have been many different solutions implemented or discussed to help alleviate this environmental crisis brewing in the Jukskei River.

The City of Johannesburg (CoJ) has implemented a program to rejuvenate the Queens Wetland which will then naturally filter out the Jukskei River by making use of micro-organisms, vegetation and the ability of these organisms to soak up nutrients. (See Appendix C, Sources from local media, part 2)

There is also a program by the CoJ where they have implemented solar powered circulators called Solar Bees to re-oxygenate the Bruma Lake, thereby stimulating the growth of natural vegetation and aquatic life. By circulating the water the levels of bacteria would also decrease. (See Appendix C, Sources from local media, part 3 and Appendix D, Interview)

The CoJ has also been building litter traps to remove any 'litter' or pollution such as garbage from the water. They have also conducted surveys to determine the extent of the damage done to the Jukskei River and possible solution for the future such as getting rid of the Bruma Lake by filling up the area and turning it back into the river with vegetation creating a new embankment for this river. (See Appendix C, Sources from local media, part 3)

Method

Field Protocol for Geography Field Assignment

1. Water Sample
    a. Collect a direct Sample from River by filling up an 800 mg Plastic screw-on bottle.
        i. Place bottle in river and fill it up with the water
        ii. Wear gloves and a mask for protection
    b. Note the odour of the water being collected
    c. Note the colour of the water
        i. Amount of visible pollutants floating in water i.e. plastic
        ii. Is there a scum on top of the water
    d. Take a photograph from the site of collection
    e. When was the last rain in the area?
    f. Use net to collect solids
        i. Take a net
        ii. Place it in river
        iii. Hold it in river for 60 seconds
        iv. Take it out of river
        v. Photograph what has been collected
        vi. Bag and tag what has been collected
        vii. Describe what has been collected
    g. Note amount of visible sediment or rocks in water
2. Soil Sample
    a. Do a soil infiltration rate test.
        i. Select A patch of ground near river on test site
        ii. Clear away the O layer of soil
        iii. Square off this patch with some cardboard
        iv. Pour 200ml into the space
        v. Measure the amount of time it takes for the water to infiltrate the ground
3. Flora and Fauna Samples
    a. Note the height tallest vegetation in the area
    b. Photograph the vegetation in the area
    c. Assess the basal cover in the near vicinity (about 1M)
    d. Estimate the tallest vegetation within a M radius in the near vicinity (about 5 paces)
    e. Identify/describe the fauna in the immediate vicinity as wells as take photographs of it and bag sample for later examination
    f. Note any visible fauna in the water and around the embankment at the test site. E.g. insects, fish, worms, birds, animals etc….
    g. Measure out 1M near the embankment of the river and determine basal cover
        i. Take stick and every 1 CM and jab it into the ground and record how many strikes of main stems are achieved
        ii. Also take photographs of the area measures
4. Note human encroachment in the area

Water Sample Processing Using Sera Quick Test Water Testing Strips

1. Immerse Sera Quick Test Strip in Water Sample for 1 second
2. Take the strip out
3. Shake off excess water
4. Wait for 60 Seconds
5. Match Colour of strip to default colours on bottle
6. Take reading
7. Take a multi-meter
8. Tape the handles of both electrodes together so that the electrodes are 1CM apart.
9. Put the multi-meter into the resistance function i.e. resistance meter
10. Change the resolution of the resistance readings to 200kΩ
11. Place electrodes into water sample, about 1 CM into the actual water sample
12. Take reading
13. Turn the multi-meter off and then back on to clear any residual memory to get an accurate reading
14. Repeat processes for all other water samples.

Processing of Findings

(see appendix D: My Own collected Data)

Excluding site 3 which is only a tributary there is a definite increase in pollution from site 1 to site 5. (see Appendix B) Even though Site 2 Bruma Lake seems to have better water quality due to rehabilitation in the area the pollution is still quite bad. There are signs of eutrophication in all the test sites. At site 1 there was some seaweed like substance which was some form of algae caught in the net which is an indication of eutrophication. At site 2 there was also a slight indication of eutrophication on the bed floor although it was much less probably from the Solar Bees that are operated in the lake. At site 3 there are signs of serious eutrophication with large algal growth occurring which is blocking the sunlight from penetrating to the bed in some of the places. At site 4 the same type of algae that was found at site 3 was found in about the same amount of density. Finally site 5 had definite signs of large scale eutrophication which was visible and highly noticeable in the river – the water had a green tint and there were green particles in the water (see photograph Appendix B, site 5). The NO_3 levels in the test sample excluding the tap water sample was way above the rating of bad and harmful amounts of NO_3 which is shown on the scale given by The Department of Environmental Affairs. (See Appendix D, Water Table Index Used by CoJ) My water tests show that there is a direct correlation between the NO_3 levels and conductivity of the water. (See appendix D) This trend shows that when the NO_3 increases so does the conductivity of the water. This shows that when NO_3 is high there are more particles in the water. The sites with the highest algae growth Sites 2, 4 and 5 have the greatest signs of eutrophication.

The tap water sample is there to provide a baseline to give some context to the results of the other water samples. The high conductivity readings for the tap water are probably due to lime and other agents put into the water by Johannesburg Water to ensure water safety.

A surprising reading was the pH levels throughout the different samples. It was relatively the same reading of around 7.2 which is in the acceptable range of the Water table index used by the CoJ. This should not be the case since of my literary sources stated that there is acid mine drainage flowing into the river. (See appendix C, Literature pertaining to the Jukskei, part 1) This could be due to my testing strips being faulty or fairly inaccurate and perhaps human error may have been involved since pH should be tested straight from the river.

The NO_2 levels in all the test samples read 0 which could also be human error or inaccurate water test strips. Another explanation could be degradation of the water samples, due to bacteria and micro-organisms living in the water while the samples were being stored awaiting testing.

The field surveys showed that certain plant life was prevalent at each test site. At each test site, I came across Caster Oil bushes, which are poisonous but indigenous to the area. (See Appendix B) I also found that there were a few varieties of grass depending on the testing site and for the most part the grass was green and seemed to be in fair health for the autumn period of the year. I also found that there were many rodents and insects prevalent. I found a bloodworm at site 1 which is also indigenous to the area. There were a few species of plant life which has been found to be alien to the area such as an unidentified yellow flowering bush at site 1, Kikuyu grass at site 2 , and a Black wattle at site 3 (See Appendix B). I also found the morning glory to be quite prevalent throughout the survey sites 1 and 3 and it may be found at other sites. There were also other indigenous plants such as the Khaki bush. I saw a lot of geese at sites 2 and 4 which are indicative of fish and water toxicity levels which are tolerable.

In an interview with two people at The Department of Environmental Affairs (See Appendix E) I found out that alien flora and fauna is introduced into this system by pollution but also by unregulated agriculture and careless people –dumping and over-growing gardens. Such alien species which thrive in this eco-system are onions and mosquito fish. I also learned there is quite are large amount of flora and fauna in the area including indigenous plant life which has been found to be quite 'hardy' and able to survive these polluted conditions while other indigenous plants have decreased in number such as the cat fish that were once numerous in the area.

The data I collected from the Department of Environmental Affairs I found to be quite strange. In some cases there are links op be made such as chemical concentration and bacterial concentration and then at other points it seems as if there are no trends. This could be indicative of false readings or human error. (See Appendix D: Graphs created from the data collected from The Department of Environmental Affairs) These graphs do show that bacterial concentrations do change at different times in the year and at some points these fluctuations coincide with fluctuations in the chemical concentration in the water. The main graphs show that at different times of the year and at different test sites there is a variety of chemicals and pollution present in the water at a varying concentration. This shows that the pollution is not consistent throughout the whole year or for a certain length of time and so the effects of this pollution may be more subtle due to short-term exposure rather than long-term exposure of said pollution.

Conclusion

I have found that as pollution increases in a river, for instance downstream, alien life will begin to form in the area and perhaps even thrive but that certain indigenous plants which have quite a high tolerance for the pollution may also thrive and even have aggressive colonisation of the area due to an increase amount of nutrients that they have access to. I have also found out that other indigenous species have begun to die due to increased eutrophication, weakened growth and weakened immunity to disease and the increase in rodents and other animals which may pose a predatory threat to these species. There is also the increase of eutrophication in the water due to the pollution which would be considered alien life to the area. This algae is known for straining the limited resources in the area thereby causing other plant life to die off.

This disproves my hypothesis from being entirely accurate since not all indigenous life in the area will die out due to pollution and some life may even thrive and aggressively take over the area – thereby competing with the alien life forming in the area. This is not what I expected from my data.

There are also limitations to my data which may not depict an accurate depiction of what is truly occurring in the Jukskei River due to pollution being present in the water and environment. The scale of my study was too small and the precision of my water test strips may not have been accurate enough to give a true account of the water conditions in the Jukskei. A better survey would cover several years and be able to show how the different seasons affect the ecosystem. Another major problem which I have found is that data posted by the different governmental departments for the Jukskei may be in dispute. There are signs that their data is not entirely accurate and may be misleading. The rehabilitation projects currently underway may have skewed my data and a false sense of reality may have been created. It is hard to determine without specific data collected before and after the rehabilitation projects were underway, the effect they are having on the Jukskei River.

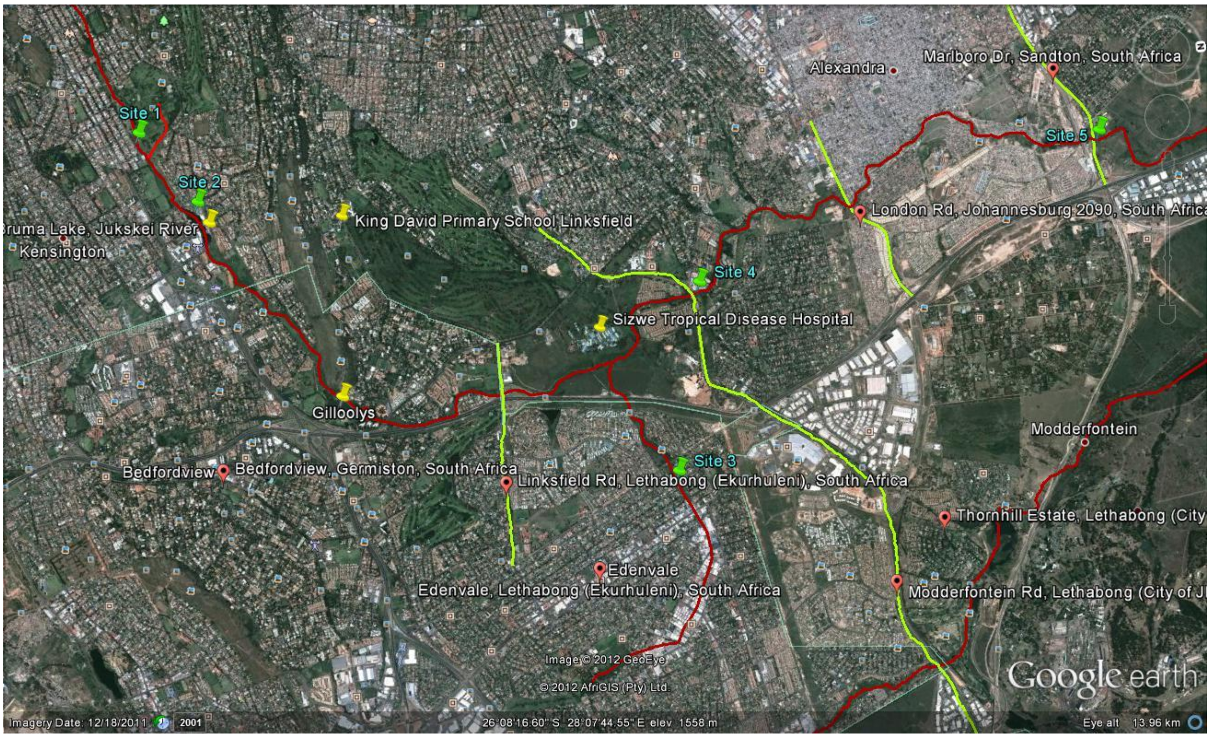
There is a link between the chemical concentration in the Jukskei and the bacterial concentration shown in the data in Appendix E. This could prove that as pollution increases so it will promote life in the area. Unfortunately this relationship between the data does not hold up throughout all the graphs and data. This is where the disputed accuracy of the data collected form the government comes in. The data I collected in Appendix B shows that the amount of ionic particles in the water increases with the amount of nitrates in the water. This also shows that as pollution (in this case NO_3) increases in the water so will the micro-biological life such as bacteria and algae.

Therefore when the pollution in a river system increases, I have found that there is the invasion of an alien species of flora and fauna to the area due to the pollution, sensitive indigenous species in the area will decline in numbers and the propagation of more tolerant indigenous species to the area will be highly evident.

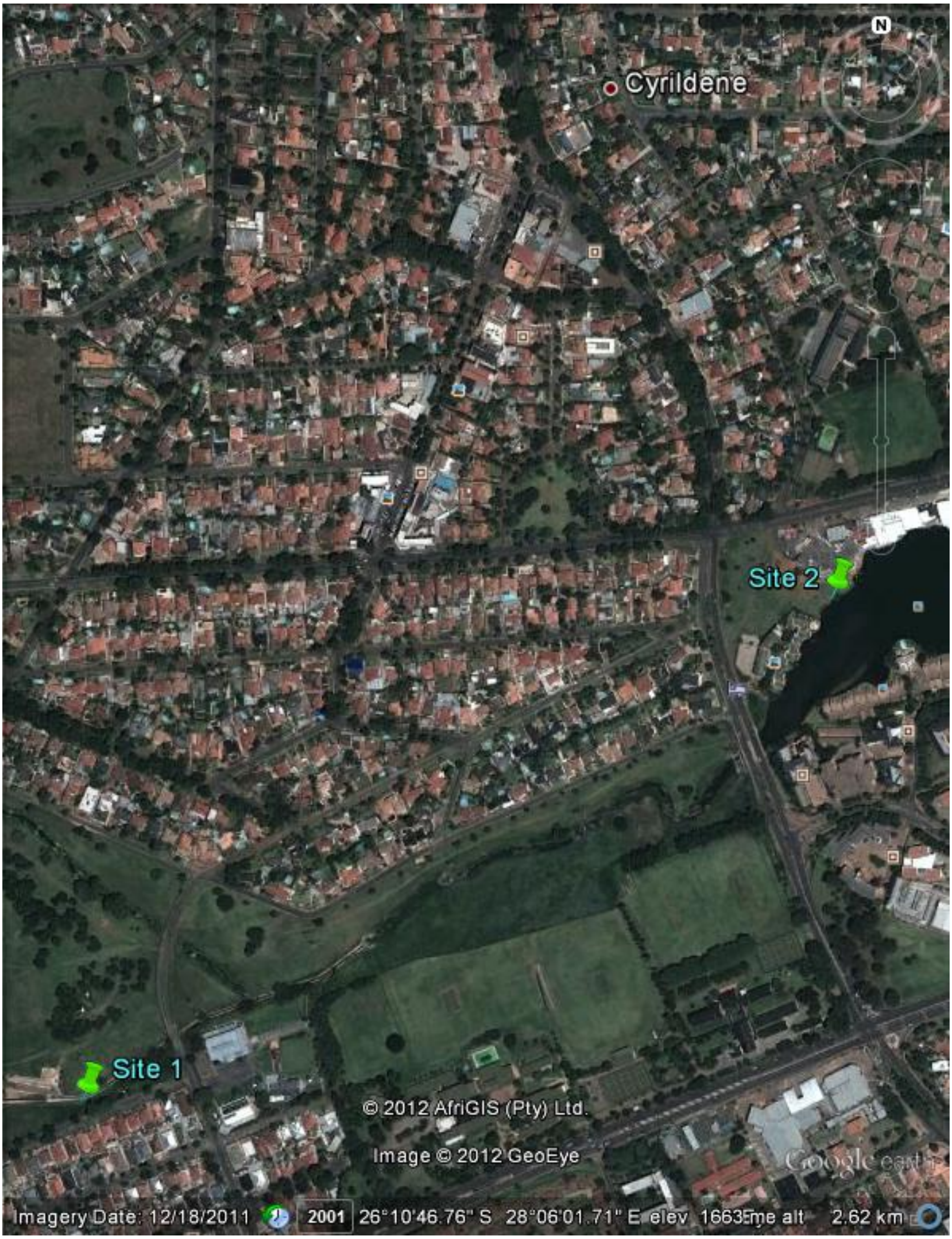
Appendix A

Location of Study and Satellite Image from Google Earth

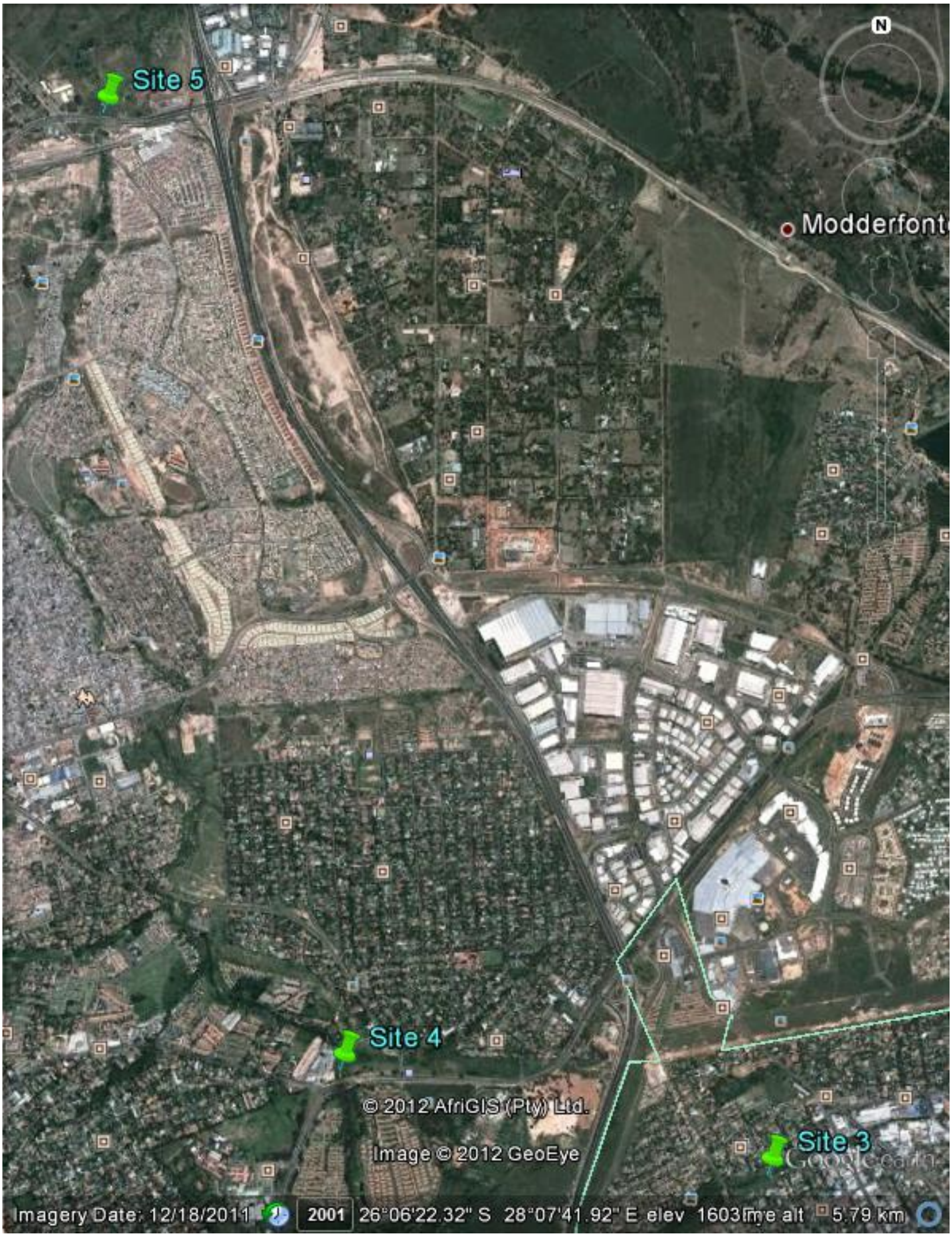
Map of whole study



Satellite Image of Sites 1 and 2



Satellite image of sites 3, 4 and 5



Appendix B

Primary Data Collected from River on 12/04/2012, plant samples, water samples and soil samples

Site 1 – Beez Valley

Field Survey Typed Out:

Odour of Water:

Smells like garbage

Colour of Water:

Has soapy scum on top. Brownish but still translucent

Solids Collected in Net:

Mulch like organic material. Perhaps seaweed, or sewerage. Clumped together.

Amount of Visible sediment in the water

The water is murky and larger sediment is visible at the bed of the river

Infiltration rate of soil at test site

15.39 Seconds

Height of tallest vegetation in the area

2M

Basal Cover in near vicinity (per M):

5 Strikes

Fauna/ flora in the immediate vicinity:

There were rats and small insects, like ticks. Off away from my site there was castor oil bushes and lots of grass cover. The park was quite overgrown but was dominated by the same type of vegetation.

There was Digitaria grass, morning glories and a few alien plants which I was unable to identify.

Note of human encroachment in the area:

There is a lot of garbage and discarded items such as plastic bottles in the area. Also there were built weirs and small levees evident.

Photographs:

Mulch like substance

Digitaria Grass – It looks very healthy and green

Morning Glory (Ipomoea nil)

Digitaria Grass

Morning Glory (purple). The yellow flower is alien
And I was unable to identify it. It has a yellow flower
with small pollen pods inside the flower. The leaves
are green and the stems are a whitish green colour
and the stems are quite soft and not rigid.

Site 2 – Bruma Lake

Field Survey Typed Out:

Odour of Water:

The odour is much better than at site 1. There is still a slightly disgusting odour but it is barely noticeable. This is probably due to municipal involvement to increase the water quality in the Bruma Lake.

Colour of Water:

Clear with black heavy silt deposited at the bottom on the lake. There are also small green patches sporadically on top of the bed floor.

Solids Collected in the Net:

There is a half decomposed leaf in the net.

Amount of Visible sediment in the water

There is lots of black sediment deposed at the bottom of the lake due to the speed of the water being slowed down and the bad construction of the lake and its dam wall.

Infiltration rate of soil at test site

7.37 Seconds

Height of tallest vegetation in the area

Low ~5CM due to being built up along the banks of the river

Basal Cover in near vicinity (per M):

12 Strikes

Fauna/ flora in the immediate vicinity:

There are worms in the soil along the embankments, there are a few fish and duck in the lake. There is artificially planted kikuyu grass along the embankment and several weeds and I even noticed a broad-leaf lily.

Note of human encroachment in the area:

There are discarded boats in the near vicinity, small paving around the embankment, a place where a fire had burned and some old burned rubber tyres. There was also some garbage stuck to the bottom of the lake.

Photographs:

Ducks and a Solar-Bee which is used to dredge the water with turbines underneath so that there is movement in the water – is an initiative to improve water quality.

Pennisetum clandestinum (kikuyu grass) Green and in Good health

Broad leaf-lily

Human encroachment and clutter evident on the Bruma Lake. The bed of the Bruma lake, filled with sediment due to illegal dumping and a experiment tried by the Department of Environmental Affairs to improve water quality in the Jukskei River network.

Site 3 – Sandspruit tributary Edenvale

Field Survey Typed Out:

Odour of Water:

The odour is more persistent than the Bruma Lake but noticeably better than site 1. It is less putrid than site 1.

Colour of Water:

The water is clear on top with lots of sediment at the bottom. The river bed also has black streaks of algae.

Solids Collected in the Net:

Seaweed like substance, some form of fresh water algae.

Amount of Visible sediment in the water

Lots of sediment deposition, braiding occurring and a sand spit/bar has been produced. The sediment consists out of small stones and clumps with large rocks deposited onto the bed and being weathered down.

Infiltration rate of soil at test site

20.58 Seconds

Height of tallest vegetation in the area

15M – 20M

Basal Cover in near vicinity (per M):

5 Strikes

Fauna/ flora in the immediate vicinity:

Found blood worms, rats, ticks and birds in the local vicinity. There is also algae in the river, black wattle trees, willows, Kikuyu grass and eucalyptus trees.

Note of human encroachment in the area:

There is evidence of sewage pipes in the river, concrete tubing, slight pollution and a road which flows over the river and therefore changes the flow of the river due to the bridge which chokes the embankment of the river at that point, making the water 'bunch up' and flow out at a greater pace.

Photographs:

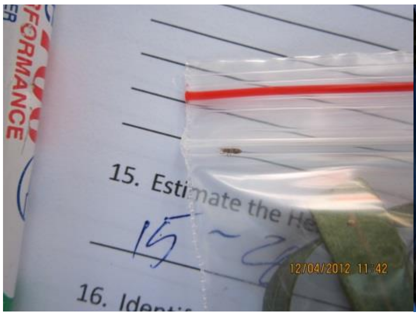
Human encroachment is evident, with a pipe dumping waste into the system. Below there is also what appears to be a round concrete tube which could be linked to the sewage network in the area.

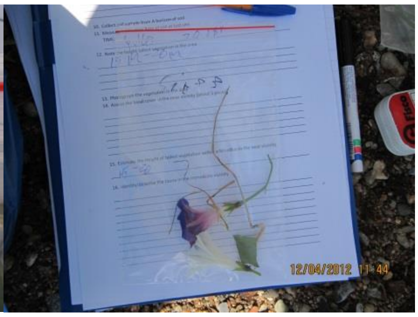
Willow, black wattle and wild olive trees.

Human encroachment and massive deposition by stream.

Algea caught in net

Themeda Trianda. Quite green and healthy





A caught insect

Morning glory

Black wattle (Acacia mearnsii De Wild) The area is also quite Green and seems healthy looking.

Eucalyptus Tree

Site 4 - Lyndhurst

Field Survey Typed Out:

Odour of Water:

There is a slight garbage smell similar to site 1

Colour of Water:

The water seems quite clear and the bed can be seen. There is also a similar algae that was found at site 3.

Solids Collected in Net:

A clump of algae was caught in the net.

Amount of Visible sediment in the water

There is dark sediment in the water and it is very fine.

Infiltration rate of soil at test site

38.36 Seconds. Note: the embankment is quite high up since this part of the river has been rejuvenated, so there is a much higher soil profile.

Height of tallest vegetation in the area

25M

Basal Cover in near vicinity (per M):

6 Strikes

Fauna/ flora in the immediate vicinity:

There is lots of moss in the river, some slight signs of eutrophication, swallows and other birds in the distance. It must be noted there are a lot of Caster Oil bushes around this area. The view of the other bank seems heavily dense with different trees and bushes. There is evidence of slight eutrophication.

Note of human encroachment in the area:

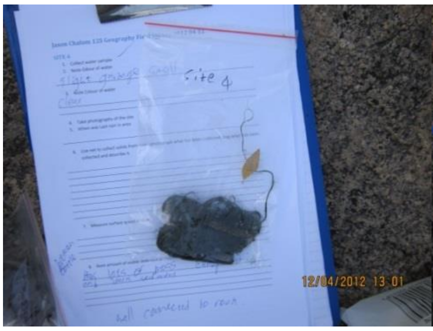
There is garbage such as a plastic bag in a tree, construction of a low wall on the kick-point is visible and there is evidence of pathways and squatting by homeless people in the area. Certain place on the embankment where the vegetation is clearer there is lots of garbage and discarded waste such as bottles.

Photographs:

A small knick-point waterfall. The trees in the distance are quite green, and there are birds in the area.

Swallow (bird)

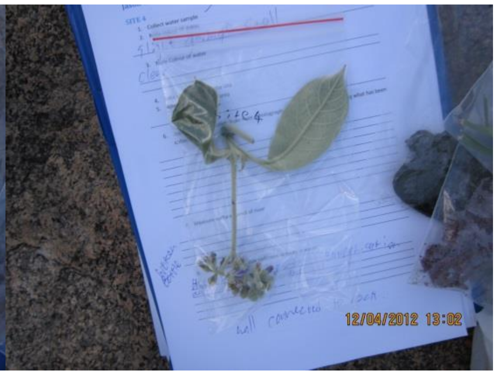
Algal growth and eutrophication on the rock



Algae (collected in net)

Castor Oil, which contains quite a lot of moisture

Kikuyu Grass



Wild Olive

The kick-point waterfall has been strengthened by the construction of a small wall, so that the river will not cut through the banks and widen at that point any more. Evidence of Human encroachment. Also Themeda trianda grass present.

Site 5 –Alexandra Outflow

Field Survey Typed Out:

Odour of Water:

The water stinks very badly and is very putrid.

Colour of Water:

The water is very dirty and noticeably green.

Solids Collected in Net:

Collected small pockets of black gunk which is unidentifiable.

Amount of Visible sediment in the water

There are a lot of rocks and sediment in the water due to construction and the township upstream.

Infiltration rate of soil at test site

30.50 Seconds

Height of tallest vegetation in the area

6-7M

Basal Cover in near vicinity (per M):

1 Strike, quite sparse at test site.

Fauna/ flora in the immediate vicinity:

There are large clumps of Castor Oil bushes in the area, khaki bushes (blackjacks) and weeds of alien origin. There are a lot of small insects such as ticks and rats.

Note of human encroachment in the area:

There is an absurd amount of pollution which is floating on the surface of the water, dumped construction materials such as rocks and construction sand similar to Durban beach sand and evidence of squatting because of a discarded and heavily used mattress left in the area. The imposing bridge with a pillar through the centre of the river is also evidence of human encroachment.

Photographs:

Note the garbage floating on the surface of the water and Castor Oil bushes in the background. The bushes at site 4 Are smaller than at other sites and the colour of the grass is not as vivid.

Human encroachment, there is building sand and rocks transported from another environment for the construction of the roads and bridges in the area. Note the eutrophication in the water and pollution.

Castor Oil, These bushes are slightly smaller than at other sites

Khaki bush, Tagetes minuta (Black-Jack bush)

Appendix C

Sources from Local Media

Part 1: Toxic Threat Under Your Feet

BY LATASHIA NAIDOO
Picture: ER Lombard Graphic: Anton Vermeulen

17 Julie 2011

TOXIC THREAT UNDER YOUR FEET

Acid mine drainage: SA's multibillion-rand environmental and health crisis

IT'S the biggest environmental threat facing the world second only to global warming, the United Nations says. And South Africans are right in the middle of the crisis, the result of more than a century of digging below the ground in Gauteng.

The problem? The devastating threat of acid mine drainage (AMD) to South Africa's economic heartland.

It's eating away at the city centre's foundations with potentially catastrophic consequences, SA's precious wildlife is being poisoned and the once lush land around Krugersdorp has become a barren, infertile desert.

For years the problem has literally been bubbling and fizzing beneath Gautengers' feet and now the government has stepped in to avert a crisis. AMD has to be urgently cleaned up and it's not going to be cheap.

Recently it was announced R442 million had been allocated to purify the acid-water pollution in Gauteng. But some environmentalists say this amount is a fraction of the billions needed to remove the threat.

Mine owners are responsible for purifying the acid water spilling from their mines. They are supposed to pump toxic waste from unused mines and filter it. But more and more companies say they can't afford the expensive treatment costs.

While companies such as Rand Uranium have been treating the acid water which has begun to spill into the western basin, other mine owners are saying the responsibility lies with those who extracted gold from the mines they now own – even though this was as far back as 120 years ago.

While mining companies have been shifting responsibility the level of the contaminated water has risen to 600 m below the surface on average, tainting clean underground water and at times even reaching the surface in low-lying areas.

It's now rising at a rate of up to almost a metre a day and environmentalists warn the situation could reach crisis levels by the end of the year, causing toxic water to spill onto the streets of Johannesburg.

But the government, which has now taken charge of the clean-up operation, remains confident the crisis can be averted.

They are looking to establish a water-treatment plant using technology developed by the Council for Scientific and Industrial Research (CSIR) which will treat about 155 million litres of AMD in the western and central basins daily.

A new pumping station is being built to pump the water out of underground basements in Johannesburg and the government estimates this project will be operational by March 2012.

With these clean-up efforts the government hopes to prevent acid mine water from coming closer than 200 m from the surface.

About R5 million has also been allocated to developing a five-year national strategy to deal with AMD in South Africa, with a specialised task team being formed to focus on curbing the threat at minimal cost to taxpayers and the government.

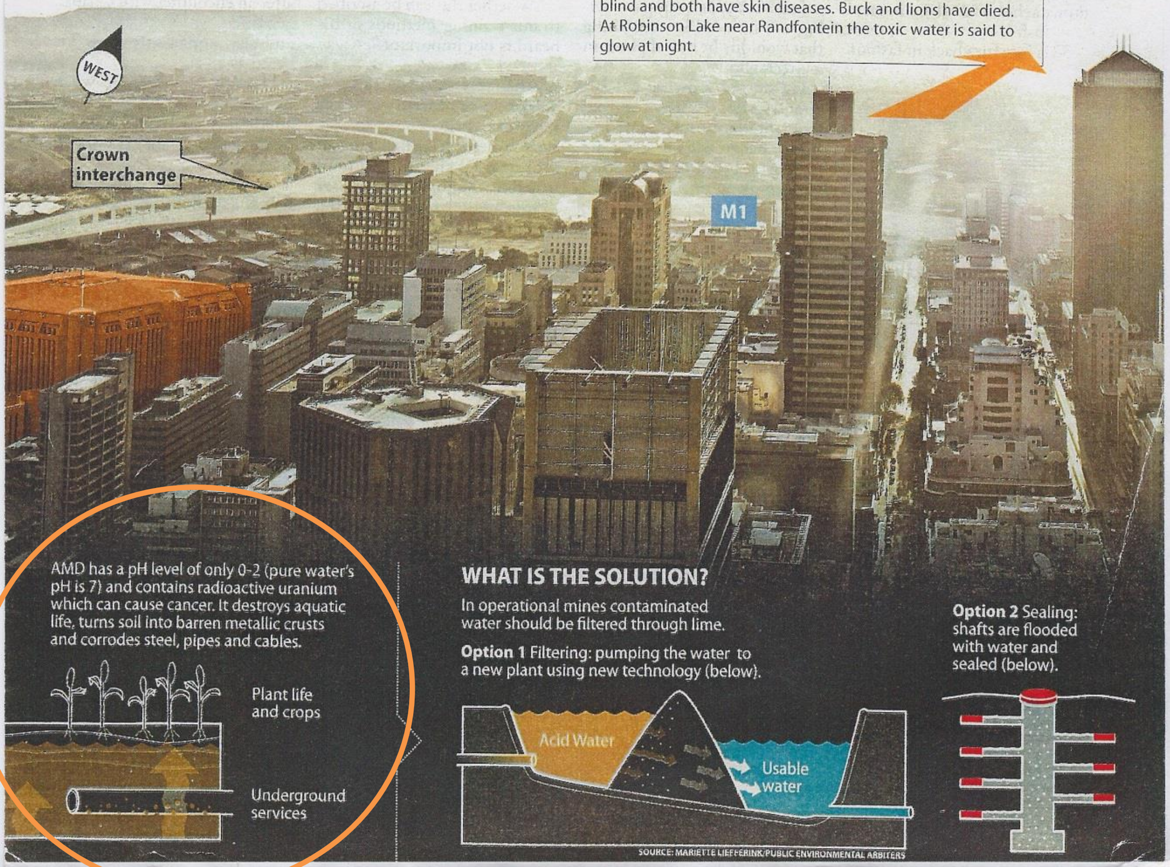
There's also a proposal on the table to flood underground mine shafts and seal them off to prevent leakage into clean water supplies. This has been done in Ohio in America with some success.

If the mines are sealed off contaminated water can't come into contact with oxygen. This means it won't become acidic and the polluted water won't flow into the clean surface water. Environmentalists in South Africa are debating the pros and cons of this method.

Clearly with a crisis of this magnitude on our hands no possible option should be ignored. □

West Rand

Wonderfonteinspruit and Tweelopiespruit's AMD pollution threatens the Cradle of Humankind and Krugersdorp game reserve. One of the two remaining hippos in the reserve is blind and both have skin diseases. Buck and lions have died. At Robinson Lake near Randfontein the toxic water is said to glow at night.



Part 2: Proposal for Bruma Lake Welcomed

Joburg East Express March 13 2012

ful," said Mr Broodryk.

He added that about two years ago the JRA did an on-site visit and said that they would put speed humps close to the school.

Ms Carol Lewin, who was the coun-

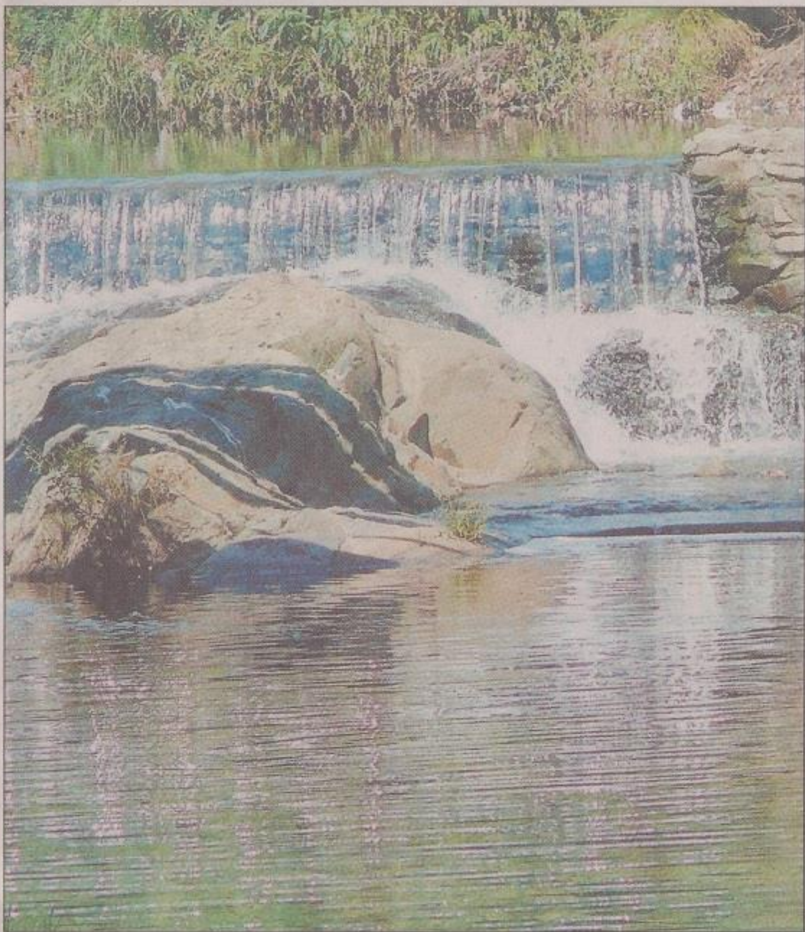
To alleviate the danger posed to pedestrians, Mr Broodryk employed three guards to help children cross the road safely. "However, it is not the best solution as the guards cannot keep an eye on everyone," he said. He also put

but we have to do it to make sure the children are safe," said Mr Marko.

The deputy principal of the school, Mrs Sandra Govender, urged the JRA to put lives of both adults and children first. "Please do something to bring

that she was waiting for a response from the relavant people and Ms Nampusheng said that someone was allocated to deal with the enquiry, at the time of going to print, no comment was received.

Proposal for Bruma Lake welcomed



The Jukskei River where it meets Bruma Lake.

A recent proposal put forward by the City of Johannesburg (CoJ) to improve the quality of water entering Bruma Lake was welcomed by the local councillor and an environmentalist.

The CoJ aims to improve the water quality by reinstating the Queens Wetland.

In a document sent to interested and affected parties recently, it was stated that the proposed reinstatement of the Queens Wetland will simulate the water quality improvement functions of natural wetlands to treat and contain surface water runoff pollutants. The proposed wetland system will comprise of three elements, a diversion structure, linear wetland and floodplain. The purification processes will include the settling of suspended solids and nutrient uptake by micro-organisms and vegetation.

The wetland is going to be developed on the section of Jukskei River between 10th and Queen streets.

"I think that this proposal is a really good idea. It will have a positive impact on the lake. This plan is one of several that needs to be put in place to improve the water quality," said Mr Paul Fairall, the chairman of the Jukskei River Catchment Area Management Forum and an environmentalist.

He added that the lake has also been somewhat clean of litter recently.

"This is due to the recent rains which have flushed the lake," he said.

Clr Alison van der Molen, ward 118, said that she welcomed the proposal but was disappointed at the lack of attendance by community members at a recent public meeting.

"There is huge concern around Bruma Lake and the effects of this on the surrounding community yet I have to question how concerned people are. The Environmental Impact Assessment meeting was poorly attended.

"People need to be advised that there will be a bit of inconvenience caused due to construction taking place when the project begins.

"We will be setting up a committee of stakeholders to keep tabs on progress but this will only work if stakeholders show interest in being involved," she said.

Part 3: Construction of Litter Traps Underway

Joburg East Express 5 June 2012

Preparation for the construction of two concrete litter traps along the banks of the Jukskei River started recently.

The litter traps will be constructed along the banks close to Queen Street and further up close to Turnstone Street.

This intervention, to bring about cleaner water flowing into Bruma Lake and downstream, is one of several interventions that City of Johannesburg (CoJ) put in place.

Measures put in place include the use of three SolarBee circulators.

A SolarBee is a floating solar powered, high flow circulator. It is used in situations requiring improved oxygenation and circulation to address water quality problems.

An E-co tap project was commissioned in December last year and Johannesburg Water undertook a sewer study upstream of the lake.

Over the past few years several residents, busine owners, environmentalists and interested partie raised concerns about the deterioration of Brum Lake and the Jukskei River.

Mr Paul Fairall, the chairperson of the Jukske River Catchment Area Management Forum an an environmentalist, said that serious health risk were likely if no action was taken to address th poor water quality.

"It is great that the CoJ is taking action. Th litter traps will make a positive difference. I als suggested the reinstatement of the Queens Wetland three years ago and I am glad the work will begi soon," he said.

CoJ recently decided to reinstate the Queens Wetland.

It is believed that the reinstatement of the Queens Wetland will simulate the water quality improvement functions of natural wetlands to treat and contain surface water run-off pollutants.

The wetland is going to be developed on the section of Jukskei River between 10th and Queen streets.

In a report handed to councillors recently by the CoJ it was stated that the city undertook a state of rivers report in 2009 which indicated that most of the rivers in the city can be considered "seriously impaired".

This was attributed to the increasing effects of sewage, urban run-off, development, sewage spills and poor infrastructure maintenance.

Some of the city's impoundments, which includes natural or man-made dams, ponds and lakes, are silted. This is because rivers or streams have challenges with sedimentation, bed modification and erosion.

Some of these impoundments were built to provide recreation, sustain aquatic habitats for biodiversity, help with stormwater control and enhance the value of properties surrounding them.

However, they are fed primarily by stormwater run-off and surface run-off that is usually polluted.

They serve as reservoirs which intercept this pollution and sediment load and this can have a negative effect as seen in areas such as Bruma.

The effects can be a silted-up impoundment of highly polluted water and a potential health-related risk due to the faecal pollution and aesthetic problems.

The functionality of some impoundments also changed over the years because of rapid development of the catchments. This led to loss of permeability due to hardened surfaces because tarred or paved areas reduce the ability of surface to absorb and retain the run-off before discharging into watercourses.

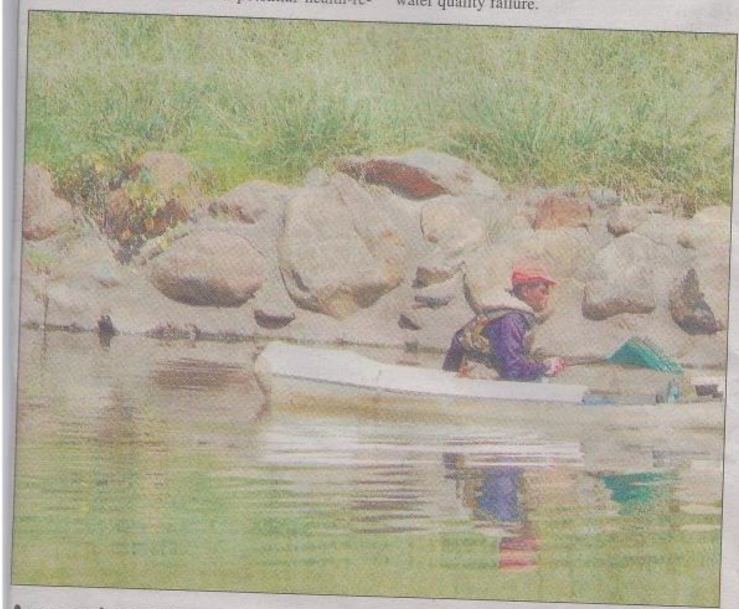
CoJ's stormwater infrastructure design is also focused on conveyance and discharge and does not provide for efficient silt, litter, energy and speed control at the point source. This results in pollution and sediment moving downstream into watercourses and impoundments leading to physical damage.

The document also stated that several CoJ departments met and reviewed the current situation to find a solution.

With regard to Bruma Lake the document states that there is a large accumulation of silt and one of the additional interventions is the prevention of sewer spills at source.

The city also aims to address poor water quality in the Rhodes Park dam.

The document stated that the potential risk or impact is the loss of recreational amenity and aquatic biodiversity. A water quality team is investigating the source of pollution contributing to the dam's water quality failure.



A man cleans Bruma Lake.

Literature pertaining to the Jukskei River

Part 1: Data from Wadzanai Matowanyika's research report

Entitled: Impact of Alexandra Township on the Water Quality of the Jukskei River

1. INTRODUCTION

The water quality of the Jukskei River in the Gauteng Province of South Africa has been monitored since 1955 by organizations such as the DWAF, WRC and City of Johannesburg. Different water quality parameters have been measured at different times depending on the objectives of the various studies. Most studies indicate that the Jukskei is polluted to some degree (e.g. Campbell 1996; Huizenga and Harmse 2005; Van Veelen 2002). Huizenga and Harmse (2005) conducted a study to compare the water quality in the Jukskei River to the Klein Jukskei River which was used as a reference stream. The Klein Jukskei River emerges from the suburbs west of the Johannesburg whereas Jukskei River's source is in the east of Johannesburg. Both rivers flow in a northerly direction and their confluence is in the north of Johannesburg (Van Veelen 2002). Huizenga and Harmse (2005) observed that between 1979 and 2002 the Klein Jukskei River had relatively low phosphate (< 0.02 mg/l) and nitrate (< 3 mg/l) concentrations whereas phosphate concentrations for the Jukskei River were mainly above 0.5 mg/l and nitrate concentrations were above 3 mg/l (Table 1.1). In 1996, the average turbidity in the Jukskei River upstream of Alexandra Township was fivefold higher than that measured downstream of the township (Campbell 1996). High nutrient concentrations in the Jukskei River have been blamed for the eutrophication of the Hartbeespoort Dam as the Jukskei is a tributary of the dam. Water quality problems of the Jukskei, especially high bacterial load, are related to urbanization (Van Veelen 2002). In 2003, the concentration of Escherichia coli in the Jukskei was 300 000 cfu/ ml, more than four orders of magnitude higher than the recommended 1 to 2 cfu/ ml (DWAF 2003). Surface water quality problems are not unique to Jukskei River, in fact most South African rivers that flow through informal settlements experience similar problems (Van Niekerk 2000). 2 Table 1.1: Water quality history in the Jukskei River downstream of Alexandra Township Parameters Years Phosphate (mg/l) Nitrate (mg/l) Ammonium (mg/l) Electrical conductivity (mS/m) pH Turbidity (NTU) 1994 0.80 5.00 22.50 89.00 8.25 25.00 1995 1.00 7.80 22.00 81.00 8.60 18.00 1996 0.75 7.80 30.00 90.00 8.25 6.00 1997 0.45 7.80 25.00 85.00 8.90 19.00 1998 0.50 5.80 16.30 75.00 8.70 20.00 1999 1.00 3.70 10.00 63.00 8.50 21.00 2006 <0.5 2.48 0.61 52.25 8.05 4.65 2007 <0.5 3.25 0.75 43.75 7.83 4.60 2008 0.55 2.78 1.07 38.93 7.58 10.73 Adapted from Campbell (1996), Van Veelen (2002) and City of Johannesburg (2009) There are 22 primary drainage regions in South Africa, the largest of which is the Orange with an annual discharge of 90.7 cubic meters per second (Chakhela 1981). Most major rivers like the Orange, Crocodile and Oliphants flow through or supply urban areas with water (Ashton and Haasbroek 2002). They are an important source of water to rural communities, agriculture, mining, domestic use in towns, wildlife, recreational activities and they also create habitats for a diverse range of aquatic animals (Davies and Day 1998). In addition to these services, rivers especially urban rivers, also affect the psychological well- being of people. In a study conducted by Maas et al. (2006) in Netherlands, it was observed that urban natural capital such as rivers and parks reduces the stress associated with urban environments and generates emotional and psychological benefits for people. Furthermore, urban rivers enhance air quality by releasing moisture and removing dust and pollutants from the atmosphere (Maas et al. 2006). Most of the rivers that flow through urban areas are under pressure partly due to the large and dense human populations that depend on the products and services that these rivers provide (Ashton and Haasbroek 2002). In 1950, 43.1 % of South Africa's population lived in urban areas, in 2005, it increased to 57.9 % and it is anticipated that by 2015 it will be 62.7 % 3 (United Nations Database 2005). The rate of population increase is higher than the number of formal houses available for people to live in which makes accommodation a problem in the country's urban areas. This has resulted in informal settlements developing to meet the demand for accommodation. According to the Department of Housing, in 1989 Gauteng contained 412 000 formal houses in the province's townships, with 422 000 shacks in their backyards and 635 000 shacks on vacant land. In 2008, 30 % of all urban housing in South Africa was classified as —shacks (Population Reference Bureau, 2008). Additionally, of the 11.89 % of South Africa's population that resides in shacks, 19.94 % of these people are in Gauteng (Statistics South Africa 2007). Informal settlements lie outside of the formal planning process and usually lack or have low levels of basic services such as water and sanitation (Abbott 2002). Overcrowding makes the removal of wastes (garbage collection) difficult and residents end up creating their own waste dumps. Informal settlements are frequently formed in the vicinity of rivers and streams, which serve as water supplies (Hranova et al. 2006). For example, the Klip River is a source of water for Gauteng Province but informal settlements near Kagiso, Durban Roodepoort Deep and western Soweto are diffuse sources of pollution to the Klip River (DWAF 1999). In addition, the informal settlements in the township of Alexandra are potential diffuse source polluters of the Jukskei River which is a tributary to the Crocodile River. The Crocodile River flows to the eutrophic Hartbeespoort Dam which provides drinking water to the city of Pretoria (Campbell 1996). 1.2 Background of Alexandra Township Alexandra Township, located 13 km North East of Central Johannesburg, South Africa (Figure 1.1), was established as a —Native Township in 1912 (Vogel 1996). The Jukskei River flows through the township and informal settlements occur mainly on the western side of the river (Figure 1.1). 4 Figure 1.1: Map showing Alexandra Township and its location relative to Johannesburg 5 The 800 hectare township saw a large population influx between 1945 and 1948 (de Jager 1990). During that period, Alexandra was not serviced with any form of basic infrastructure (de Jager 1990). Population continued to increase in the township and in 1963, in an effort to upgrade Alexandra, the government legislated that a limit of 35 000 people were to be housed in single dwelling units (de Jager 1990). As a result, between 1964 and 1973, 56 000 people were forcibly moved to Soweto and about 15 000 to Tembisa (de Jager 1990; Morris 2000). Nevertheless, Alexandra's population continually increased. Between the years 1987 and 1990 an —Urban Renewal Plan was implemented. Full engineering services, including a water reticulation system, water-borne sewage, electrical reticulation and on-stand ablution facilities were provided to all dwelling units in Alexandra (Campbell 1996). The improvements, however, attracted more people. Alexandra's population increased from approximately 30 000 in the mid 1920s to an estimated range of 470 000 to 750 000 in 2001 (Wilson 2002). This was partly due to depleted economies and wars in neighboring countries which resulted in influx of immigrants into Johannesburg (de Wet et al. 2001). Furthermore, with the abolition of the influx legislation in 1986, many people moved from rural to urban areas to seek employment. Alexandra became a destination, and mass immigration resulted in informal settlements putting a heavy demand on the township's infrastructure. Faced with this situation, President Thabo Mbeki, in 2001 launched the Alexandra Renewal Project (ARP) which aimed to replace informal settlements with formal government housing (ARP 2001). By May 2008, 1 400 free houses had been built in the Extension 7 area of Alexandra (ARP 2008), but accommodation is still limited and sanitation standards are still low in Alexandra. People dwelling on the banks of the Jukskei discard sewage and litter directly into the river. Overflowing chemical toilets, oil, kitchen waste and detergents are potential sources of pollution to the Jukskei River.

Found on page 9

2. WATER QUALITY Water quality includes the microbiological, physical, chemical and radiological properties of water (WRC 1998). Many of these properties are controlled or influenced by substances which are either dissolved or suspended in water (Palmer et al. 2004). Water quality affects the biota that live in a river and it also affects the suitability of the water in the river for uses such as drinking, agriculture or recreation (Skoroszewski 1999). A river is polluted when it is either directly or indirectly altered due to human activity resulting in the modification of ecological systems to an extent that harm occurs to the resident aquatic life or to humans (Lloyd 1992; Ellis 2005). Pollution can come from point or diffuse sources. Point or ―end of pipe sources are associated with man-made discharges from industrial activities, municipal wastewater collection and treatment systems and other activities (Hranova 2006). Diffuse or non-point sources are associated mainly with land drainage and surface runoff, which enters a water body by dispersed and poorly defined ways. Diffuse pollution in urban areas is associated mainly with polluted urban runoff (drainage) contaminated with materials washed off of streets, roads, roofs, open spaces etc. (Hranova 2006). According to DWEA (2009) urbanisation in South Africa is associated with increased non-point pollution of rivers. Organic wastes produced by humans are not very different in composition to natural products of leachates of plant and animal origin from land surfaces (Lamb 1985). The main distinction between the two inputs is the much higher concentration of pollutants discharged by humans living in high density settlements. Dilution here is insufficient to reduce these concentrations to natural levels, the quality of the receiving water declines and its capacity to support various uses is impaired (Tchobanoglous and Schroeder 1985). Anthropogenic alteration of the biological and chemical functions in a river can result in increased primary 10 production, algal blooms and reduced habitat availability. Furthermore, anthropogenic influences on water systems can cause ecosystem destruction, which results in species and population extinction (Malmqvist and Rundle 2002). 2.1 Physical Water Quality Variables 2.1.1 Temperature Climate, structural features and anthropogenic activities of a river catchment area influence its thermal conditions (Palmer et al. 2004). Increases in water temperature normally result in decreased oxygen solubility and may also increase the toxicity of certain chemicals, both of which may result in increased stress in many aquatic organisms (Palmer et al. 2004). Aquatic organisms like some fishes require specific temperature for spawning and the development of eggs and young (Petts 1984). 2.1.2 Turbidity, total suspended solids and suspended particulate organic matter Turbidity and total suspended solids (TSS) are important physical water quality parameters where turbidity is a measure of water clarity. TSS refers to the suspended materials in a water column comprising an inorganic fraction (silts and clays) and an organic fraction SPOM, which includes algae, zooplankton, bacteria, and detritus (McAlister and Ormsbee 2005). Small particles suspended in water scatter and absorb light, giving the water a murky or turbid appearance (Lamb 1985). High concentrations of TSS reduce water clarity and decrease light available to support photosynthesis. TSS in high concentrations has also been shown to alter predator-prey relationships – e.g. turbid water might make it difficult for fish to see their prey

(Lamb 1895). Increases in turbidity often result from release of domestic sewage, industrial discharge (including mining, pulp and paper manufacturing) and physical perturbations such as road use, road and bridge construction (Palmer et al. 2004). 11 2.2 Chemical water quality variables 2.2.1 pH The concentration of hydrogen (H+) and hydroxyl ions (OH-) in water give a measure of pH (Palmer et al. 2004). Most fresh waters are almost neutral, pH of 6-8 (Davies and Day 1998). The type of rocks and minerals in a catchment usually determines the pH of a river (Lamb 1985). pH is a critical determinant of many biological functions; pH that is too high or too low may damage an organism by interfering with its metabolic processes (Lamb 1985). Human-induced acidification of rivers is normally the result of industrial effluents, mine drainage and acid precipitation. 2.2.2 Dissolved oxygen (DO) Dissolved oxygen is of fundamental importance in maintaining aquatic life and is therefore one of the most widely used water quality variables (Tchobanoglous and Schroeder 1985). DO is the amount of gaseous oxygen dissolved in water, which enters surface waters through reaeration. Oxygen is also released into water as a product of photosynthesis (Selman 2007). Factors causing a decrease in DO (hypoxic conditions) in rivers include elevated temperature and salinity, respiration of aquatic organisms, decomposition of organic materials by microorganisms and chemical breakdown of pollutants (Palmer et al. 2004). Dissolved oxygen concentrations in water should range from 70 to 120 % saturation (Selman 2007). Hypoxic systems, having DO concentrations below 30 %, have detrimental effects on some aquatic organisms depending on a species sensitivity and stage of development (eggs, larvae or adult) (DWAF 1996a). 2.2.3 Electrical conductivity (EC) Another important chemical water quality parameter is EC, the ability of water to conduct electrical current (Palmer et al. 2004). EC increases as the concentration of ions (most importantly, calcium, magnesium and bicarbonate) increases (Tchobanoglous and Schroeder 1985). 12 2.2.4 Nitrate, ammonium and phosphate Nitrogen (as nitrate or ammonium) and phosphorous (orthophosphate) are essential nutrients for the growth of aquatic plants and animals (Lamb 1985). For this reason, these compounds are nutrients or biostimulants when discharged as wastewater to rivers (Tchobanoglous and Schroeder 1985). On entering rivers, phosphorous is dissolved in the water column as PO43-or adsorbed onto soil and other particles (Lamb 1985). High concentrations of phosphorous occur in waters that receive sewage, leaching or runoff from cultivated land (Palmer et al. 2004) and also detergents. In South Africa, phosphorous is seldom present in high concentrations in unimpacted surface waters because it is actively taken up by plants and thus under natural conditions concentrations between 10 and 50 µg/l are commonly found (DWAF 1996a). Nitrogen enters rivers via sewage, municipal and industrial wastewater and runoff from fertilized agricultural fields (Lamb 1985). Sewage waste is high in nitrogen in the form of urea and upon entering water bodies; the urea is converted into ammonium (NH4+). NH4+ is then converted to nitrite (NO2-) through the assimilation of the bacteria Nitrosomonas. Nitrobacter bacteria convert NO2- to nitrate (NO3-) and this nitrification process consumes oxygen thereby decreasing the concentration of dissolved oxygen in the water (Brisbin and Runka 1995). Nitrate-N and ammonium-N are essential plant nutrients (Skoroszewski 1999). In well oxygenated waters (80 – 120 % DO), ammonium-N concentrations will be below 0.1 mg/l N (DWAF 1996a). NH4+-N + NO3--N concentrations less than 0.5 mg/l N are considered to be sufficiently low that they can limit eutrophication (DWAF 1996a). Nitrogen and phosphate can stimulate the growth of algae which provide food for higher organisms (invertebrates and fish). However an excess of nitrogen or phosphorous can result in the over-production of plankton. When the plankton die and decompose, they 13 consume oxygen in the water leaving other oxygen-dependent organisms stressed (Palmer et al. 2004). 2.3 Microbiology Total coliform bacteria concentration is normally used as an indicator of the microbiological quality of water (Keller 1960). These bacteria are a collection of relatively harmless microorganisms that live in the intestines of both warm- and cold-blooded animals (Lamb 1985). A specific subgroup of this collection is the fecal coliform bacteria, the most common member being Escherichia coli (E. coli) (Tchobanoglous and Schroeder 1985). The difference between E. coli and other coliforms is that E. coli is found exclusively in the faeces of warm-blooded animals while other coliforms are naturally found in vegetation, soil, water and faeces. E. coli in water bodies indicates recent contamination by sewage or animal waste and it also indicates the presence of disease-causing bacteria, viruses and protozoa (Health Canada 2006). For these reasons, E. coli is considered to be the species of coliform bacteria that is the best indicator of human fecal pollution and the possible presence of pathogens (Keller 1960). Pathogenic organisms in water can be transferred to humans through water consumption (Diesch, 1970). For example potential diseases that can be transferred to humans from cattle waste containing pathogens are salmonellosis, anthrax, tuberculosis, tetanus, colibacilosus etc (Azevedo and Stout 1978). The presence of E. coli, especially when above 100-200 counts per 100 ml, is an indicator of a potential health risk for individuals exposed to this water (DWAF 1996c). According to Dallas and Day (2004), it is possible that South African rivers that pass through or those close to informal settlements with no waterborne sanitation and meagre water supplies are severely contaminated by faecal pathogens. 14 2.4 Seasonal Variation in water quality Surface water quality generally changes with seasons (McAlister and Ormsbee 2005). Seasonal variations have been reported in water quality parameters such as EC, TSS, pH, temperature, oxygen and nutrients (Nelson et al. 1996). For example, in a study conducted on the Long Indian River in Florida, ammonium, nitrite and phosphate concentrations were significantly higher in the wet season than in the dry season (Doering 1996). Seasonal variations in precipitation, surface runoff and ground water flow have a strong effect on the concentration of pollutants in river water (Vega et al. 1998). In South Africa, Highveld cold dry seasons (May to October) lead to decreased water temperature. TSS, EC and turbidity tend to be lower during winter periods as there is less rainfall and runoff from a river’s catchment (Clarke 1993). During the wet season (November to April), increased discharge, high turbulence and increased aeration in rivers result in high DO concentrations. Rivers also tend to be more turbid during the rainy season due to increased eroding power (Koning and Roos 1999).

Part 2: Extract from: Diatoms as indicators of water quality in the Jukskei-Crocodile river system in 1956 and 1957, a re-analysis of diatom count data generated by BJ Cholnoky

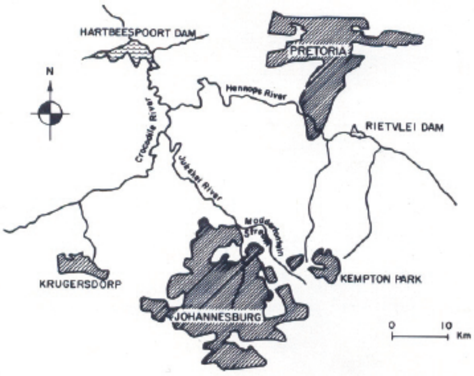


Figure 1
Location of the Jukskei-Crocodile River catchment area (Schoeman, 1982)

2004). A widely accepted definition of eutrophication is that of the Organisation for Economic cooperation and Development (OECD, 1982) which describes the process as "… *the nutrient enrichment of waters which results in the stimulation of an array of symptomatic changes, amongst which is the increased production of algae and aquatic macrophytes, deterioration of water quality and other symptomatic changes that are found to be undesirable and interfere with water uses*". In the classification of Nauman (1919) and Rast and Thornton (1996) the term oligotrophic means the presence of low levels of nutrients and water quality problems; mesotrophic means intermediate levels of nutrients, with emerging signs of water quality problems; and eutrophic means high levels of nutrients and an increased frequency of water quality problems.

The aim of this study is to demonstrate the value of historical diatom analysis sheets by showing that they can be used as the basis for calculating a diatom index score for a particular site. This diatom index core can in turn be useful for drawing conclusions about the past condition (up to 50 years ago) of South African rivers.

Methods

The Jukskei-Crocodile River system drains an area of 2 046 km^2 between Johannesburg and the Hartbeespoort Dam at an alti-

study this was achieved by entering the data first into spreadsheets and then into the OMNIDIA database. The first entry into MICROSOFT EXCEL was necessary as the data had to be electronically captured. However, if the person entering the data is proficient in the use of the OMNIDIA Database the data can be directly entered without a first, time-consuming, entry into spreadsheets. OMNIDIA (Lecointe et al., 1993) was developed for the management of diatom samples and calculation of diatom indices from abundance data generated from diatom community analysis. Data entry into OMNIDIA only requires a species acronym together with absolute abundance of the relevant diatom species. From these data the program generates the full species name and relative abundance of the species in the community, and hence is far less time-consuming than entering species data into spread- sheets. Results obtained from OMNIDIA are in the form of individual diatom analysis sheets together with site information, relative abundance of the species, population, diversity, evenness and a number of diatom index scores generated from the diatom community data (see discussion above). Alternatively diatom analysis sheets can be grouped together up to 20 at a time saving repetitive mention of species. These files can then in turn be exported to EXCEL or some other similar program.

The entry of diatom data of a historical nature using the acronym method poses several problems for the inexperienced user. The first complication that arises is whether the species name used by the original author of the analysis sheets is currently valid and recognized by the software? The validity of species names can be checked in OMNIDIA or, failing that, in a number of literature resources. If the specific or generic epithet is no longer valid then the accurate synonym can be obtained in the OMNIDIA program, or alternatively from literature resources such as Krammer and Lange-Bertalot (1986 to 1991) or Kellogg and Kellogg (2002). Secondly, the relevant acronym for data entry needs to be identified. There is a printable list of acronyms in OMNIDIA for about 9 000 species, or alternatively an electronic search may be conducted by typing the full species name into OMNIDIA. The acronym construction follows certain rules and once the operator is familiar with these rules most of the acronyms can many times be determined without resorting to either a manual or electronic search.

Once the data had been entered, the database (OMNIDIA) calculated the indices listed above in the introduction. In the following section the diatom index results for this analysis will be presented and discussed.

Results and discussion

Literature pertaining to the Effect of Nitrates in Water

Nitrates in the Aquarium
http://freshaquarium.about.com/od/watercare/a/nitrates.htm

By Shirlie Sharpe, About.com Guide

The significance of nitrates in the aquarium is arguably less understood by fish keepers than the effect of ammonia and nitrites. Although nitrates are not directly lethal in the way ammonia or nitrites are, over time high levels of nitrate have a negative effect on fish, plants and the aquarium environment in general.

Effect on Fish
Fish will feel the impact of nitrates by the time the levels reach 100 ppm, particularly if levels remain there. The resulting stress leaves the fish more susceptible to disease and inhibits their ability to reproduce.

High nitrate levels are especially harmful to fry and young fish, and will affect their growth. Furthermore, conditions that cause elevated nitrates often cause decreased oxygen levels, which further stress the fish.

Nitrates and Algae
Elevated nitrates are a significant contributor to undesirable algae growth. Nitrate levels as low as 10 ppm will promote algae growth. Algae blooms in newly setup tanks are usually due to elevated nitrate levels.

Although plants utilize nitrates, if nitrates rise faster than the plants can use them, the plants can become overgrown with algae, ultimately leading to their demise.

Where Do Nitrates Come From?
Nitrates are a by-product of nitrite conjugation during the latter stages of the nitrogen cycle, and will be present to some degree in all aquariums. Detritus, decaying plant material, dirty filters, over-feeding, and over-stocking the tank, all contribute to increased production of nitrates.

Water used to fill the aquarium often has nitrates in it. In the United States, drinking water may have nitrates as high as 40 ppm. Before adding water to your tank test, it for nitrates so you know if the levels are unusually high in your water source. If nitrates are above 10 ppm, you should consider other water sources that are free of nitrates.

Desired Level
In nature nitrates remain very low, generally well below 5 ppm. In freshwater aquariums nitrates should be kept below 50 pm at all times, preferably below 25 ppm. If you are breeding fish, or are battling algae growth, keep nitrates below 10 ppm.

How to Reduce Nitrates

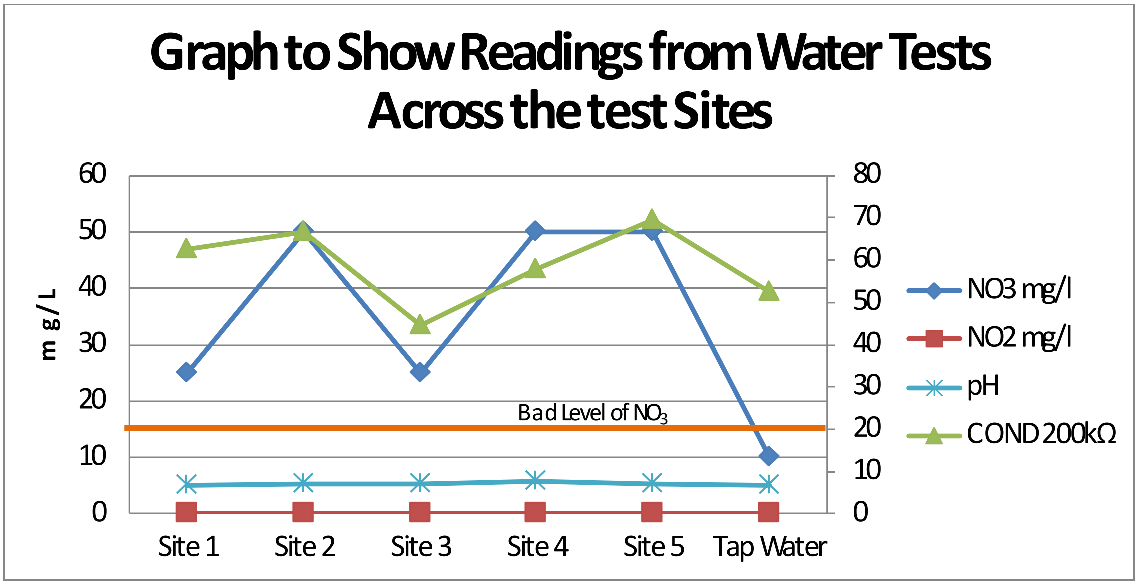
Unlike ammonia and nitrites, the bacteria that remove nitrates do not like oxygen rich environments. Therefore, conventional filters do not harbor the bacteria that remove nitrates. Although special filters exist that will remove nitrates, such devices are usually expensive compared to other filtration units. However, there are some steps you can take to keep nitrates low.

- **Keep the tank clean** – Waste ultimately produces nitrates. Cleaner tanks produce fewer nitrates in the first place.
- **Don't overfeed the fish** – Overfeeding is a significant contributor to excess nitrates and other undesirable wastes, such as phosphates.
- **Water changes** – Performing regular water changes with water that has little or no nitrates will lower the overall nitrate level in the tank. RO/DI water is an excellent choice for keeping nitrate levels low.
- **Keep live plants** – Live plants utilize nitrates, and will help keep nitrates in check.
- **Use nitrogen removing filter media** – Instead of an expensive denitrator or special filter, use special media in the filter you have. Although they will not lower nitrates dramatically, if used together with other methods the net result will be beneficial

Appendix D

Water Quality Tests from Different Sources, Including graphs created for this project from the raw data

My Own Collected Data



*The Bad level baseline found from data collected from the Department of Environmental Affairs (See Appendix E, titled: Water Table Index Used by CoJ)

Raw Data That I Collected From Water Samples

Tests on Water Done with water testing strips												
Location	**Test 1**						**Test 2**					
Test	NO3 mg/l	NO2 mg/l	GH	KH	pH	COND 200kΩ	NO3 mg/l	NO2 mg/l	GH	KH	pH	COND 200kΩ
Site 1	50	0	>6	3	7.2	57.5	25	0	>6	3	6.8	62.6
Site 2	50	0	>6	3	7.2	50.8	50	0	>6	3	7.2	66.6
Site 3	25	0	>10	3	7.2	37.4	25	0	>10	3	7.2	44.6
Site 4	50	0	>10	3	7.2	53.9	50	0	>10	3	7.6	57.8
Site 5	50	0	>10	3	7.2	61.7	50	0	>10	3	7.2	69.4
Tap Water	10	0	>6	3	7.2	48.8	10	0	>6	3	6.8	52.3

*Site 3 is the Edenvale, Sandspruit tributary which flows into the Jukskei River, so it will have disparities to the other readings

Interview with The Department Of Environmental Affairs

What is your name and what is your job at the Department of Environmental Affairs?

I am Bensen Mpete and I am the senior specialist for water quality management. My job is to go into the field and collect water samples for testing.

I am Support Chavalala and I am the assistant director of biodiversity and conservation. My job entails that I go into the field and conduct field analysis surveys to monitor the ecology around the Jukskei River network.

In what way does your job involve you with the Jukskei River?

It is the key area in our responsibility.

Is The Jukskei River highly polluted?

Yes it is but you must make your own observations from the data we are giving you.

What pollutants are found in the Jukskei River?

There is sewerage, e-coli and other forms of bacteria. There is also dumped garbage and alien species that have been spread by people unintentionally. There is sandy material as well.

What is being done to improve the river conditions?

There have been a few NGO initiatives and government initiatives which have been attempted to try and alleviate the pollution problem. We have implemented Solar Bees which dredge the bottom of the Bruma Lake and circulate the water to try and improve the situation there. We have also placed a litter trap near the Beez Valley section and we have built Weirs there to stop incoming sediment falling in. We are also looking at reinstating a wetland in that area. The lake also has storm water drains which dumps lots of litter so we will be adding litter traps there as well. We have only done some trails with eco-tabs but they are too expensive. There is also the Alexandra Renewal Project taking place.

What types of plant life are usually found near and on the embankments of the river?

The whole area has been infested by some exotic species. There is eucalyptus and wetland reeds.

What animals and insects have their natural habitat on or around the Jukskei River?

Ducks, rats, micro-invertebrates. There is high pollution so those which are tolerant. Egyptian Geese, cat fish and exotic species like mosquito fish.

There are not many cat fish found in the area.

How has the plant life in or near the river changed due to the pollution in the river?

Generally- germinating season exotic species come in. There are signs of high eutrophication.

What types of diseases or Bacteria has been found near the Jukskei River? What health problems are people who live or work near the river experiencing?

e-coli is the only bacteria which we test for.

What forms of rehabilitation is being done on the Jukskei River Network?

There are litter traps, weirs to stop erosion. Adding silt. Reinstate wetlands. At lake storm water litter baskets, and solar bees. Cleaning project initiative at Bruma Lake. Alexandra – Adopt a River which is removing the litter and debris. Removal of litter which is sponsored by province. Bioremediation – bio-tabs.

What construction has been done on or around the river? How has this affected the plant life and animal life in the area?

Weirs and Gabions.

Does pollution have a direct impact on the life sustained by a river?

Yes, only species which are tolerant survive.

Are periodical tests being done on the Jukskei River system? If So where?

Monthly, e-coli and a range of tests. Water quality – phosphates, pH, and Nitrates as well as some others.

What types of data is collected during these tests?

Biodiversity – rather we do not do tests but assessments on the plants and animals in the area.

Are there new exotic or alien flora and fauna in the area due to pollution?

Yes, expansion of existing cultivation makes invasive plants flourish. It is a very big problem. Onions have been found in the area.

Does pollution in the River affect the shape of the river by changing its stream pattern and deposition/erosion ability?

Yes. Dumping, rubble and chemicals affects the flow of the river.

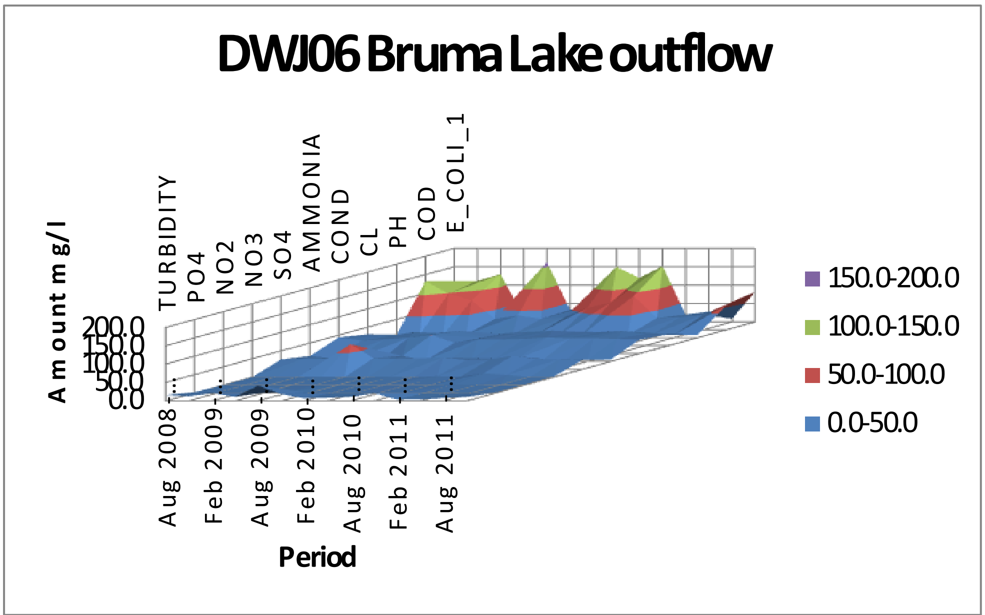
What is the life cycle of e-coli?

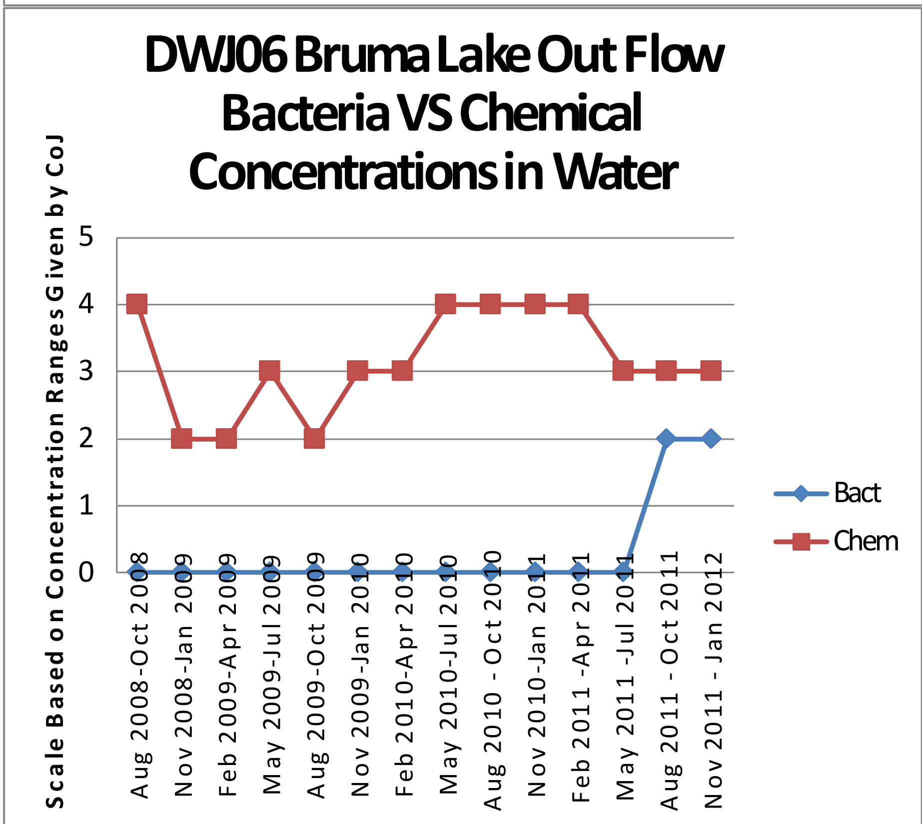
The e-coli likes more still water to flourish.

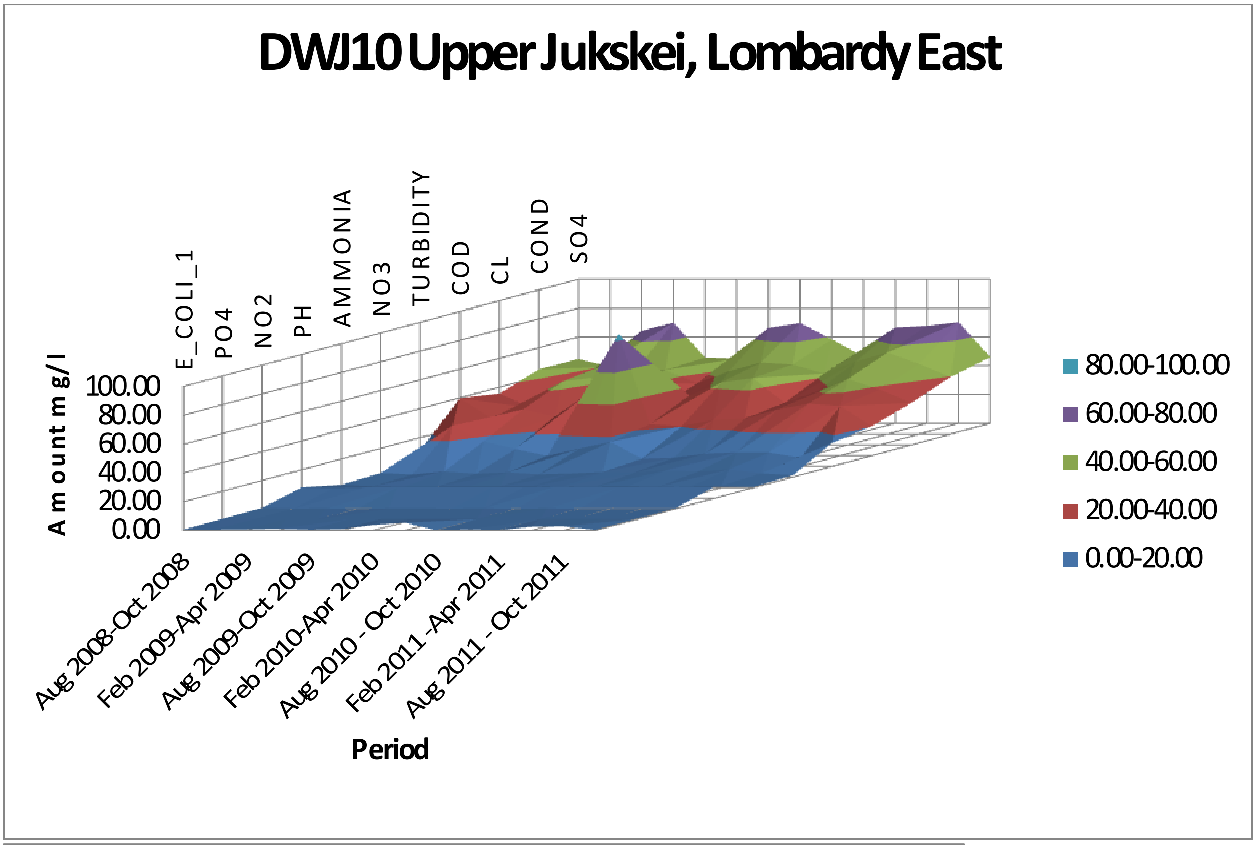
Appendix E

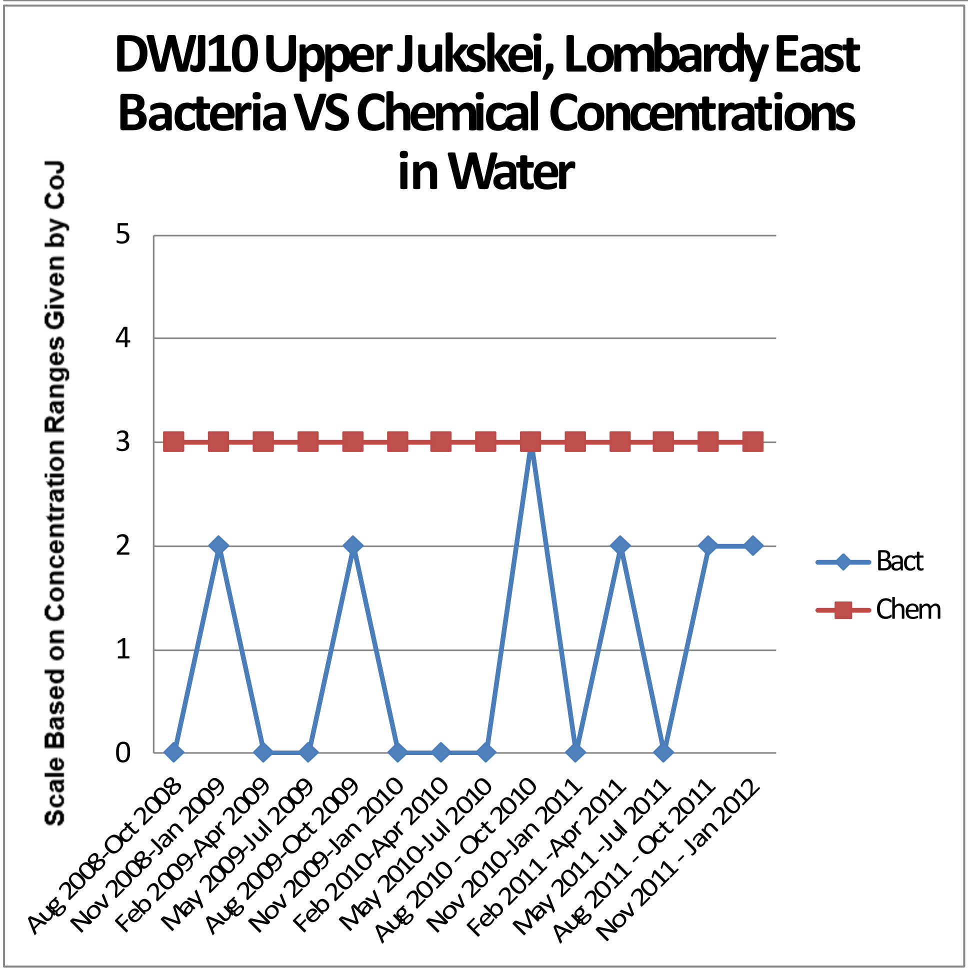
Graphs

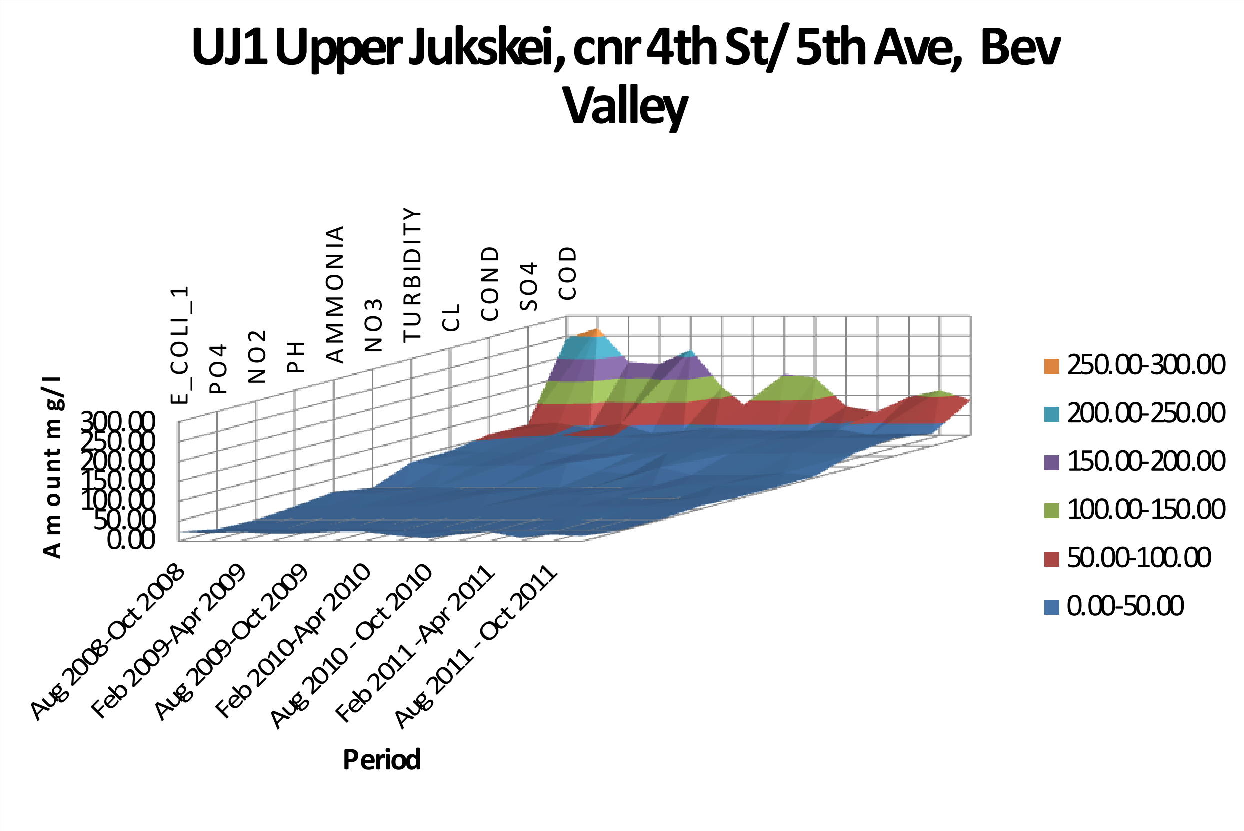
Graphs I created from the data collected from The Department of Environmental Affairs The data in this appendix is largely not used because there are some problems with the usefulness of the data. It is included for perspective in how a larger study may yield different results. This data in some cases shows certain relationships while at other sites these relationships do not exist. I cannot explain this discontinuity and so have decided not to use this data as a main source of information for my research assignment. The graphs showing bacterial and chemical concentration was created from the scale given later on in the raw data and water table index.

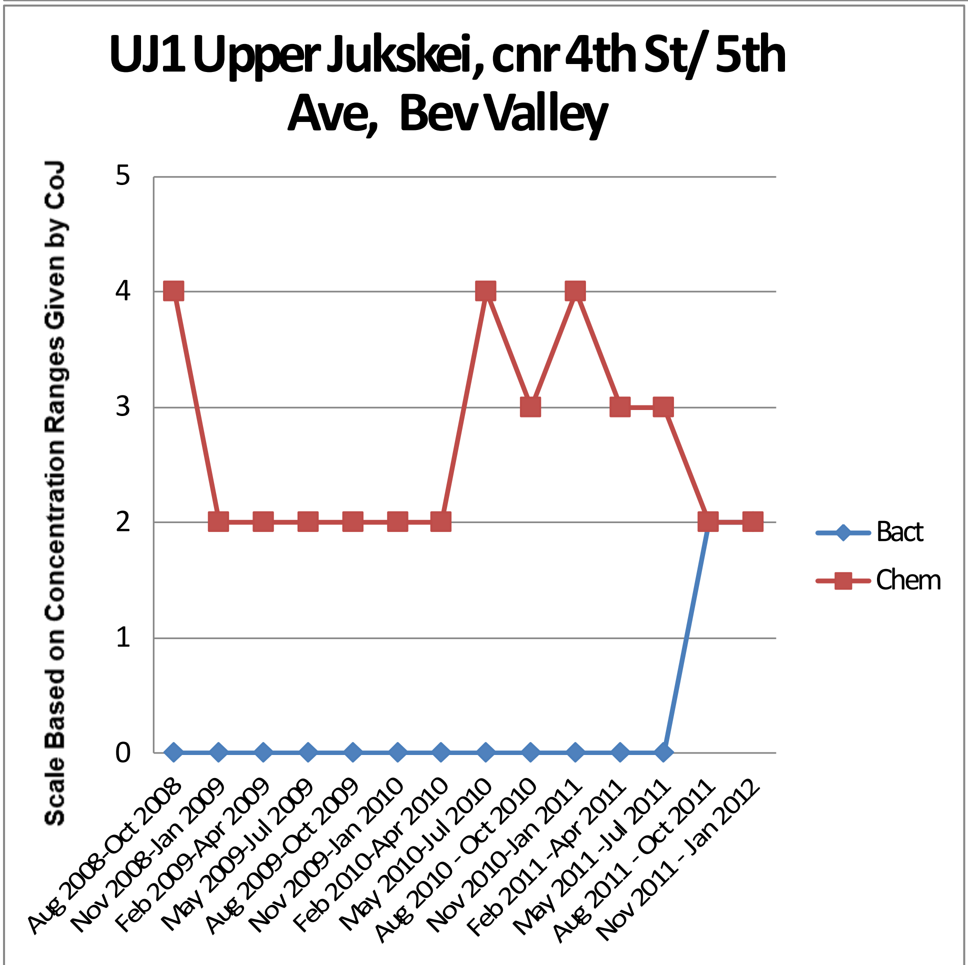


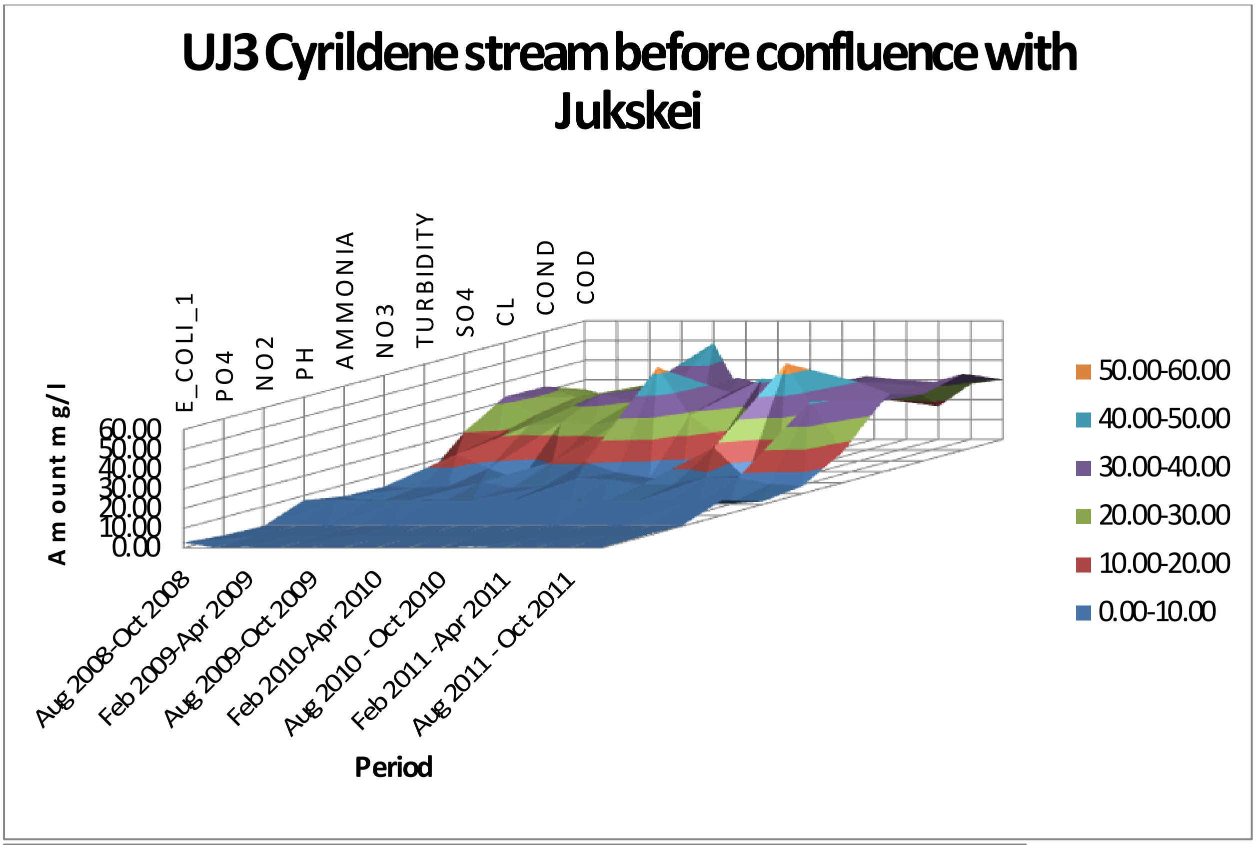


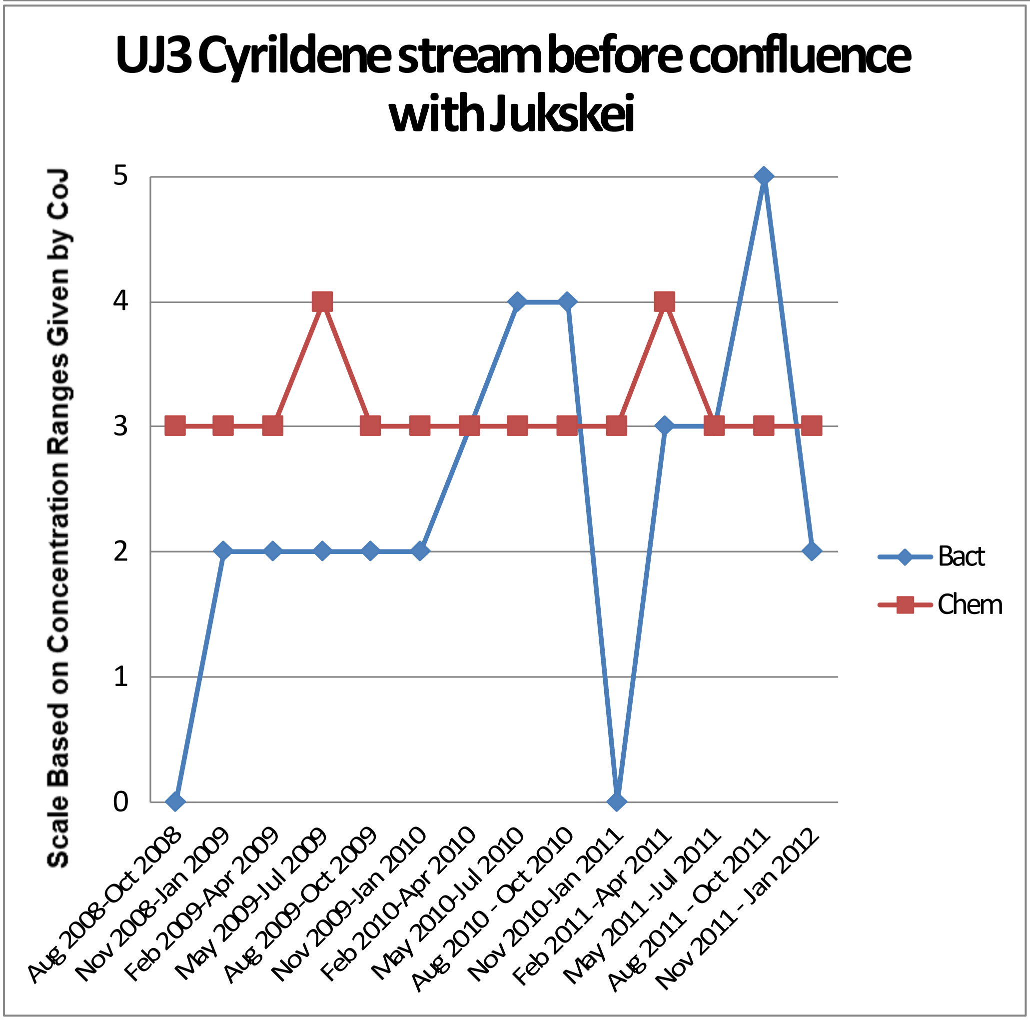

DWJ10 Upper Jukskei, Lombardy East
A m ount m g/l
100.00
80.00
60.00
40.00
20.00
0.00
E_COLI_1
PO4
NO2
PH
AMMONIA
NO3
TURBIDITY
COD
CL
COND
SO4
Aug 2008-Oct 2008
Feb 2009-Apr 2009
Aug 2009-Oct 2009
Feb 2010-Apr 2010
Aug 2010 - Oct 2010
Feb 2011 -Apr 2011
Aug 2011 - Oct 2011
Period
80.00-100.00
60.00-80.00
40.00-60.00
20.00-40.00
0.00-20.00

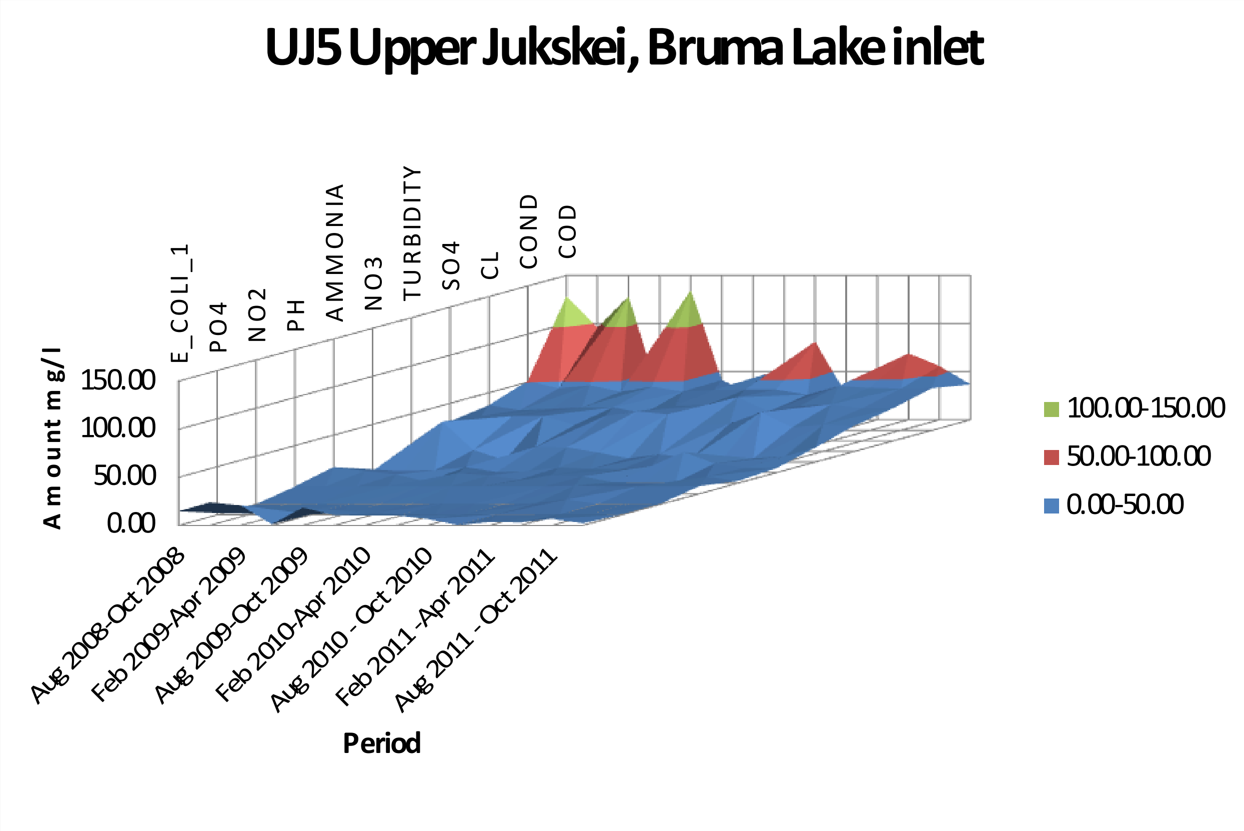

DWJ10 Upper Jukskei, Lombardy East Bacteria VS Chemical Concentrations in Water
Scale Based on Concentration Ranges Given by CoJ
5
4
3
2
1
0
Aug 2008-Oct 2008
Nov 2008-Jan 2009
Feb 2009-Apr 2009
May 2009-Jul 2009
Aug 2009-Oct 2009
Nov 2009-Jan 2010
Feb 2010-Apr 2010
May 2010-Jul 2010
Aug 2010 - Oct 2010
Nov 2010-Jan 2011
Feb 2011 -Apr 2011
May 2011 -Jul 2011
Aug 2011 - Oct 2011
Nov 2011 - Jan 2012
Bact
Chem

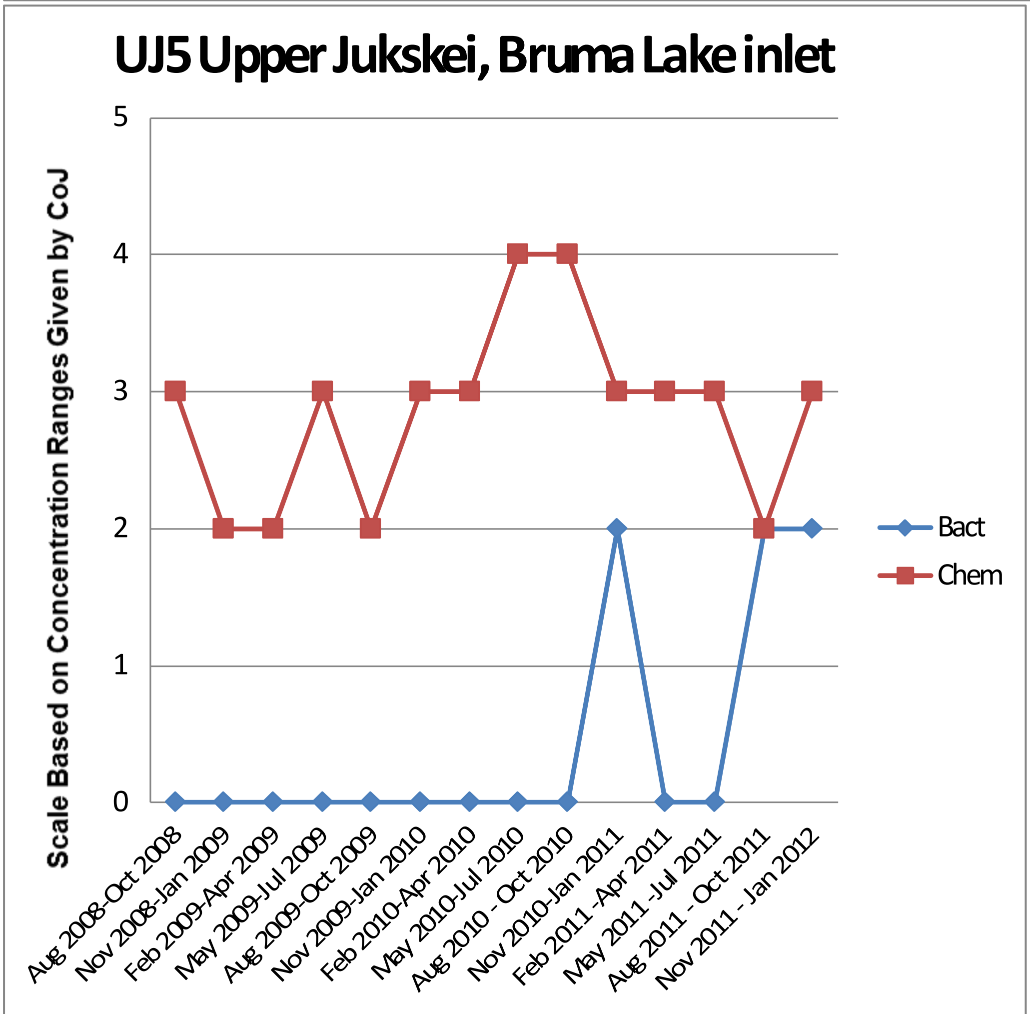

UJ1 Upper Jukskei, cnr 4th St/ 5th Ave, Bev Valley
Amount mg/l
300.00
250.00
200.00
150.00
100.00
50.00
0.00
E_COLI_1
PO4
NO2
PH
AMMONIA
NO3
TURBIDITY
CL
COND
SO4
COD
Aug 2008-Oct 2008
Feb 2009-Apr 2009
Aug 2009-Oct 2009
Feb 2010-Apr 2010
Aug 2010 - Oct 2010
Feb 2011 -Apr 2011
Aug 2011 - Oct 2011
Period
250.00-300.00
200.00-250.00
150.00-200.00
100.00-150.00
50.00-100.00
0.00-50.00

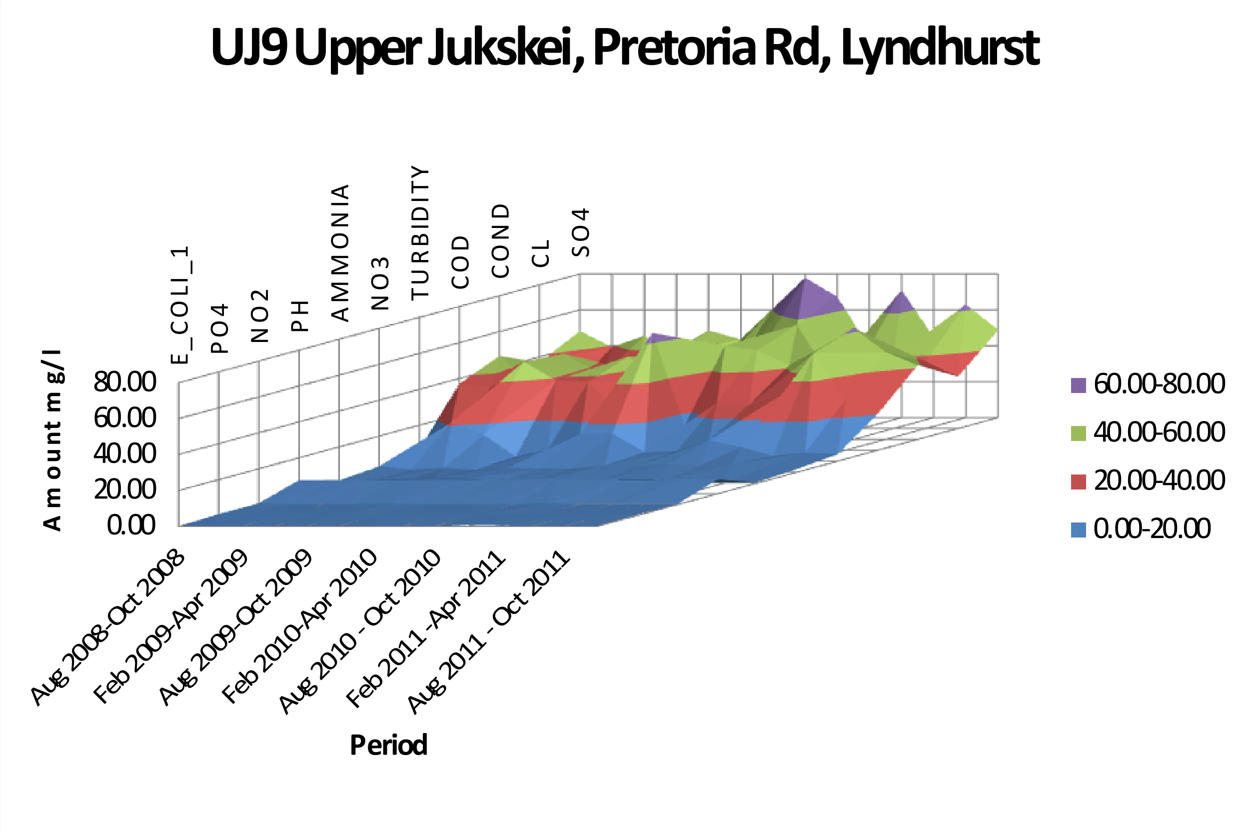

UJ1 Upper Jukskei, cnr 4th St/ 5th Ave, Bev Valley
Scale Based on Concentration Ranges Given by CoJ
5
4
3
2
1
0
Aug 2008-Oct 2008
Nov 2008-Jan 2009
Feb 2009-Apr 2009
May 2009-Jul 2009
Aug 2009-Oct 2009
Nov 2009-Jan 2010
Feb 2010-Apr 2010
May 2010-Jul 2010
Aug 2010 - Oct 2010
Nov 2010-Jan 2011
Feb 2011 -Apr 2011
May 2011 -Jul 2011
Aug 2011 - Oct 2011
Nov 2011 - Jan 2012
Bact
Chem


UJ3 Cyrildene stream before confluence with Jukskei
Amount mg/l
60.00
50.00
40.00
30.00
20.00
10.00
0.00
E_COLI_1
PO4
NO2
PH
AMMONIA
NO3
TURBIDITY
SO4
CL
COND
COD
Aug 2008-Oct 2008
Feb 2009-Apr 2009
Aug 2009-Oct 2009
Feb 2010-Apr 2010
Aug 2010 - Oct 2010
Feb 2011 -Apr 2011
Aug 2011 - Oct 2011
Period
50.00-60.00
40.00-50.00
30.00-40.00
20.00-30.00
10.00-20.00
0.00-10.00

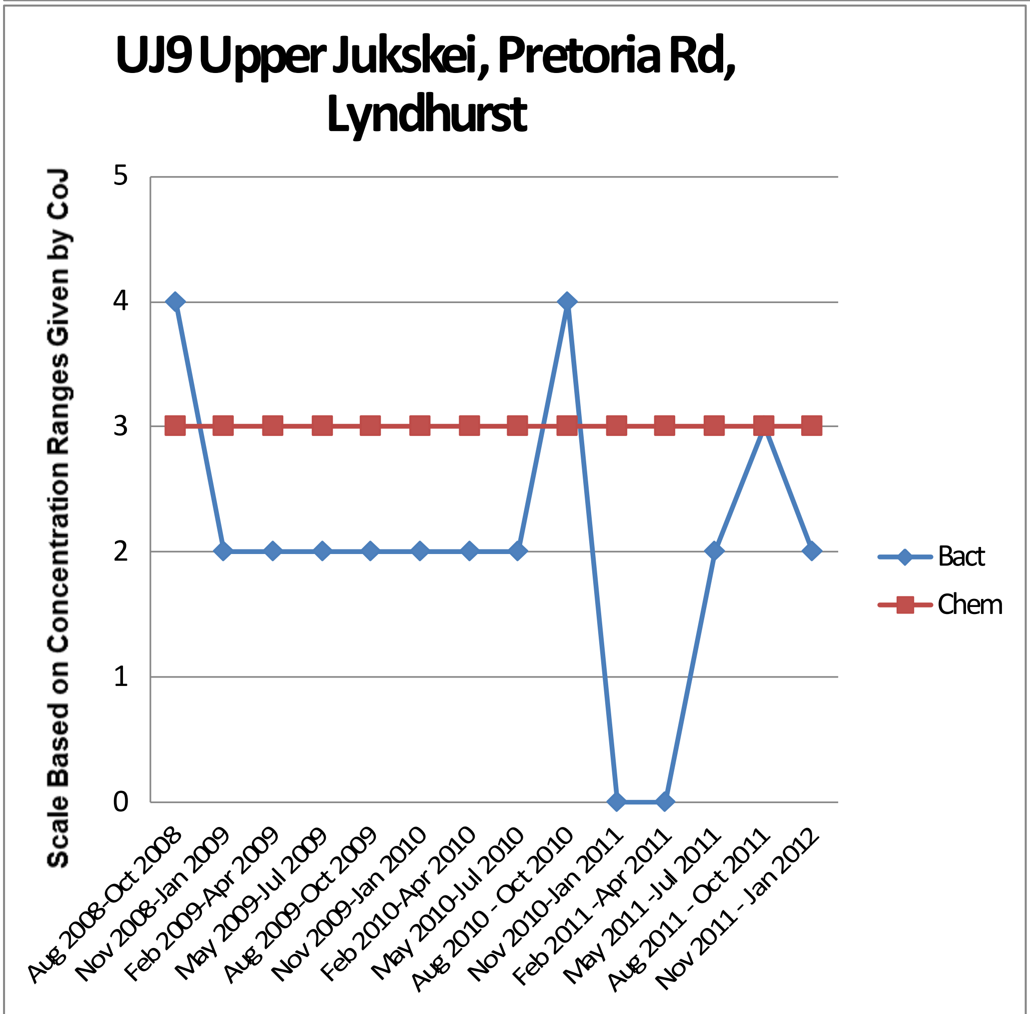

UJ3 Cyrildene stream before confluence with Jukskei
Scale Based on Concentration Ranges Given by CoJ
5
4
3
2
1
0
Aug 2008-Oct 2008
Nov 2008-Jan 2009
Feb 2009-Apr 2009
May 2009-Jul 2009
Aug 2009-Oct 2009
Nov 2009-Jan 2010
Feb 2010-Apr 2010
May 2010-Jul 2010
Aug 2010 - Oct 2010
Nov 2010-Jan 2011
Feb 2011 -Apr 2011
May 2011 -Jul 2011
Aug 2011 - Oct 2011
Nov 2011 - Jan 2012
Bact
Chem


UJ5 Upper Jukskei, Bruma Lake inlet
A m ount m g/l
150.00
100.00
50.00
0.00
E_COLI_1
PO4
NO2
PH
AMMONIA
NO3
TURBIDITY
SO4
CL
COND
COD
Aug 2008-Oct 2008
Feb 2009-Apr 2009
Aug 2009-Oct 2009
Feb 2010-Apr 2010
Aug 2010 - Oct 2010
Feb 2011 -Apr 2011
Aug 2011 - Oct 2011
Period
100.00-150.00
50.00-100.00
0.00-50.00


UJ5 Upper Jukskei, Bruma Lake inlet
Scale Based on Concentration Ranges Given by CoJ
5
4
3
2
1
0
Aug 2008-Oct 2008
Nov 2008-Jan 2009
Feb 2009-Apr 2009
May 2009-Jul 2009
Aug 2009-Oct 2009
Nov 2009-Jan 2010
Feb 2010-Apr 2010
May 2010-Jul 2010
Aug 2010 - Oct 2010
Nov 2010-Jan 2011
Feb 2011 -Apr 2011
May 2011 -Jul 2011
Aug 2011 - Oct 2011
Nov 2011 - Jan 2012
Bact
Chem



UJ9 Upper Jukskei, Pretoria Rd, Lyndhurst
Amount mg/l
80.00
60.00
40.00
20.00
0.00
E_COLI_1
PO4
NO2
PH
AMMONIA
NO3
TURBIDITY
COD
COND
CL
SO4
Aug 2008-Oct 2008
Feb 2009-Apr 2009
Aug 2009-Oct 2009
Feb 2010-Apr 2010
Aug 2010 - Oct 2010
Feb 2011 -Apr 2011
Aug 2011 - Oct 2011
Period
60.00-80.00
40.00-60.00
20.00-40.00
0.00-20.00



UJ9 Upper Jukskei, Pretoria Rd, Lyndhurst
Scale Based on Concentration Ranges Given by CoJ
5
4
3
2
1
0
Aug 2008-Oct 2008
Nov 2008-Jan 2009
Feb 2009-Apr 2009
May 2009-Jul 2009
Aug 2009-Oct 2009
Nov 2009-Jan 2010
Feb 2010-Apr 2010
May 2010-Jul 2010
Aug 2010 - Oct 2010
Nov 2010-Jan 2011
Feb 2011 -Apr 2011
May 2011 -Jul 2011
Aug 2011 - Oct 2011
Nov 2011 - Jan 2012
Bact
Chem

RAW Data and Locations of Municipal Test Sites

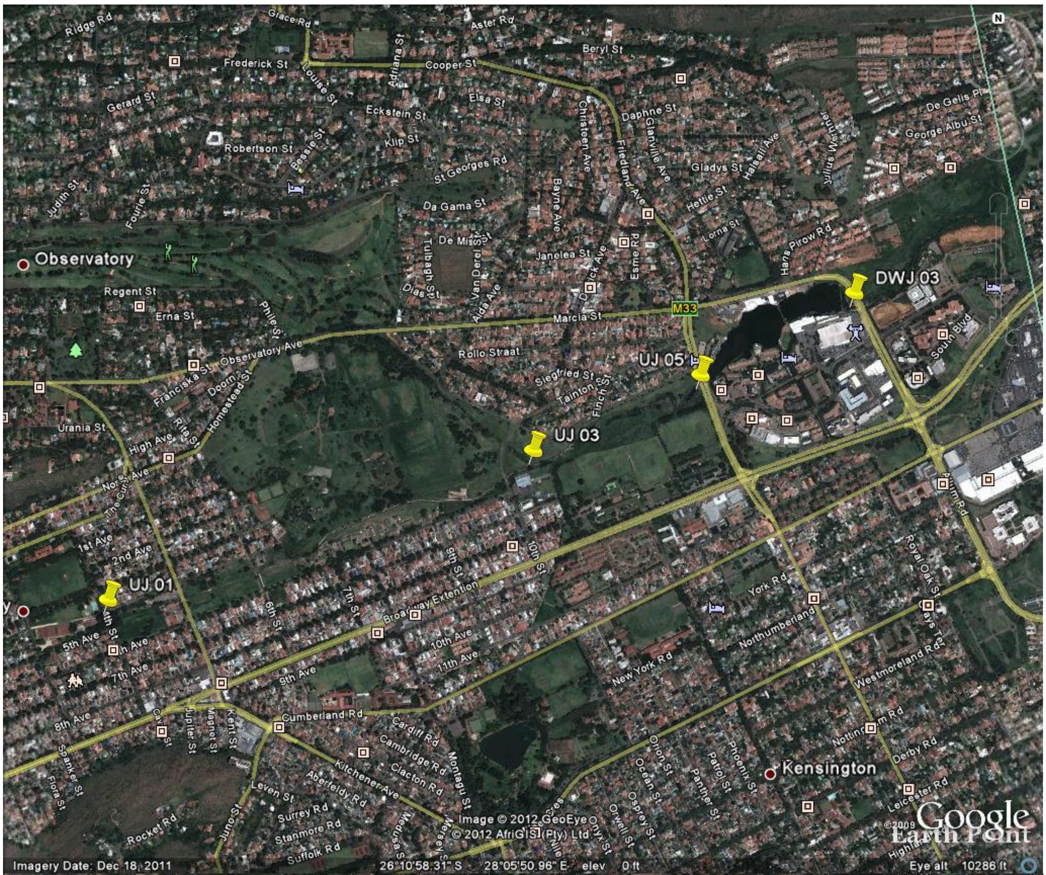
ınesburg
ıter Quality Status of the Jukskei Catchment — August 2008 -Janaury 2012

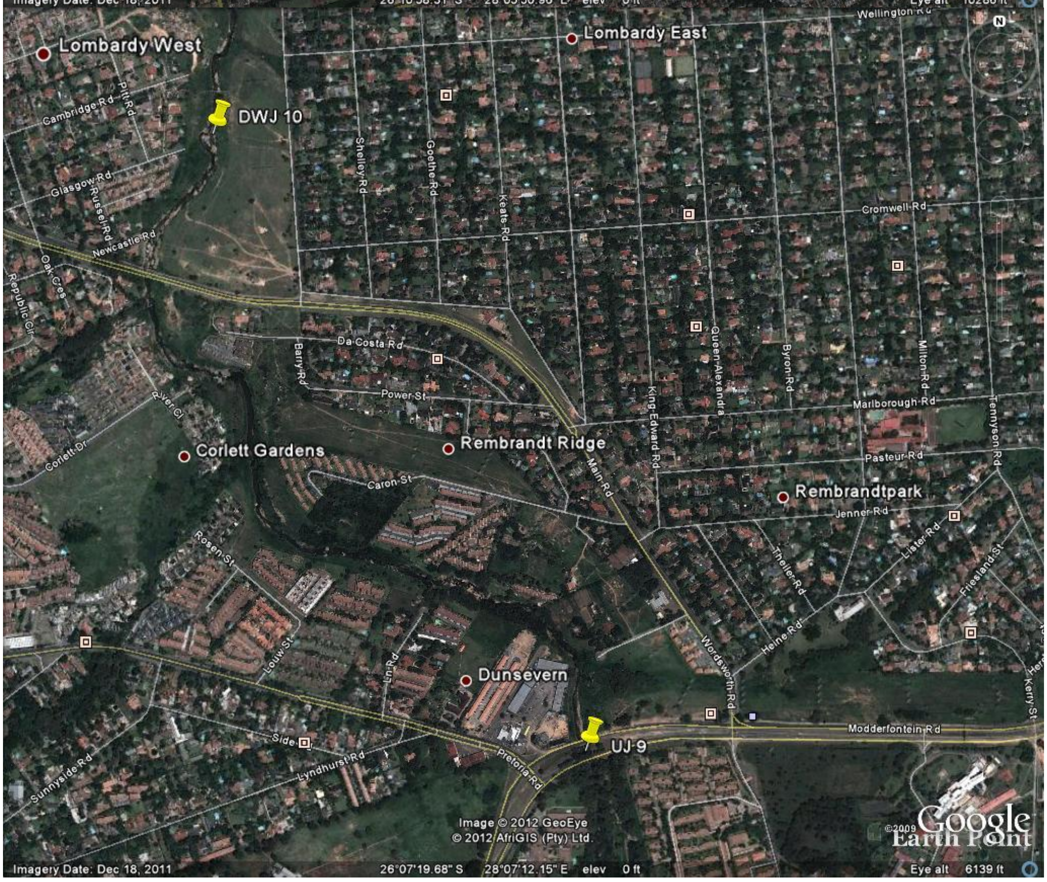
ɔburg
class african city

Aug 2008 -January 2012

Sample Description	PERIOD	E_COLI_1	E_COLI_1 to Nearest 10000	PO4	NO2	NO3	AMMONIA	COND	PH	COD	TURBIDITY	CL	SO4	Bact	Bact Using given Range	Chem	Chem Using Given Range
	Aug 2008-Oct 2008	1075000	107.50	2.45	0.2	0.5	14.67	43.7	7.2	132.3	15.8	30.8	26.8	Bad	0	Good	4
	Nov 2008-Jan 2009	1116200	111.62	1.30	0.4	1.1	7.94	35.0	7.3	99.0	12.8	26.2	29.8	Bad	0	Unacceptable	2
	Feb 2009-Apr 2009	1293333	129.33	1.23	0.2	0.9	7.53	38.7	7.0	80.2	21.9	36.8	28.5	Bad	0	Unacceptable	2
	May 2009-Jul 2009	137600	13.76	0.5	0.1	2.2	0.62	43.0	7.8	29.5	11.3	34.0	68.0	Bad	0	Acceptable	3
	Aug 2009-Oct 2009	1622833	162.28	3.73	0.8	0.6	15.02	50.8	7.2	39.3	41.3	40.2	30.7	Bad	0	Unacceptable	2
	Nov 2009-Jan 2010	333333	33.33	0.63	0.2	0.9	2.47	28.7	7.3	30.3	18.4	21.1	29.3	Bad	0	Acceptable	3
Bruma Lake outflow	Feb 2010-Apr 2010	463333	46.33	0.65	0.3	1.9	3.00	38.3	7.2	33.3	7.1	34.0	30.0	Bad	0	Acceptable	3
	May 2010-Jul 2010	1496667	149.67	1.30	0.5	0.7	6.33	38.0	7.1	60.0	8.4	37.3	32.0	Bad	0	Good	4
	Aug 2010 - Oct 2010	1196667	119.67	0.90	0.2	3.2	7.00	40.0	7.3	74.3	11.1	41.0	25.0	Bad	0	Good	4
	Nov 2010-Jan 2011	1516667	151.67	1.36	0.8	1.8	8.70	43.7	7.2	92.3	21.0	37.7	26.7	Bad	0	Good	4
	Feb 2011 -Apr 2011	194333	19.43	0.5	1.9	10.8	1.08	41.5	7.3	32.0	4.1	36.8	36.8	Bad	0	Good	4
	May 2011 -Jul 2011	283333	28.33	0.56	1.3	6.1	0.50	41.7	7.2	34.7	3.8	40.0	28.0	Bad	0	Acceptable	3
	Aug 2011 - Oct 2011	89033	8.90	0.70	0.1	0.7	4.33	39.7	7.8	41.0	7.6	32.3	27.3	Unacceptable	2	Acceptable	3
	Nov 2011 - Jan 2012	825000	82.50	0.88	0.1	0.5	4.87	38.3	7.4	67.0	10.9	30.7	25.3	Unacceptable	2	Acceptable	3
	Aug 2008-Oct 2008	51550	0.52	0.76	0.9	2.8	1.96	45.0	7.7	39.7	11.3	35.5	44.7	Bad	0	Acceptable	3
	Nov 2008-Jan 2009	48000	0.48	0.5	0.4	1.8	0.87	32.2	7.2	25.6	28.0	25.6	39.2	Unacceptable	2	Acceptable	3
	Feb 2009-Apr 2009	72333	0.72	0.5	0.5	3.9	0.50	47.5	7.7	32.0	17.4	44.0	64.3	Bad	0	Acceptable	3
	May 2009-Jul 2009	116800	1.17	0.5	0.1	2.3	0.63	42.5	7.7	27.0	12.0	34.0	70.0	Bad	0	Acceptable	3
	Aug 2009-Oct 2009	43667	0.44	0.5	0.5	3.2	0.78	44.5	7.7	42.2	7.3	41.8	45.7	Unacceptable	2	Acceptable	3
	Nov 2009-Jan 2010	89800	0.90	0.5	0.5	1.9	0.77	35.3	7.6	84.3	12.3	25.3	45.0	Bad	0	Acceptable	3
Upper Jukskei, Lombardy East	Feb 2010-Apr 2010	390000	3.90	0.5	0.4	2.5	0.77	43.7	7.6	21.7	17.0	34.3	66.3	Bad	0	Acceptable	3
	May 2010-Jul 2010	543333	5.43	0.5	0.6	3.4	1.12	49.7	7.6	20.3	5.3	43.3	69.7	Bad	0	Acceptable	3
	Aug 2010 - Oct 2010	1233	0.01	0.5	0.2	3.0	0.50	48.3	8.2	24.7	6.0	46.3	58.3	Acceptable	3	Acceptable	3
	Nov 2010-Jan 2011	68733	0.69	0.5	0.6	4.6	0.78	42.0	7.9	25.7	8.9	29.0	46.3	Bad	0	Acceptable	3
	Feb 2011 -Apr 2011	23833	0.24	0.5	0.2	3.8	0.50	50.3	7.8	31.8	9.8	36.8	66.5	Unacceptable	2	Acceptable	3
	May 2011 -Jul 2011	268000	2.68	0.50	0.1	5.3	0.50	56.7	7.7	36.0	9.7	45.7	67.7	Bad	0	Acceptable	3
	Aug 2011 - Oct 2011	290913	2.91	0.58	0.2	2.6	1.27	48.7	7.9	34.3	6.0	38.3	70.3	Unacceptable	2	Acceptable	3
	Nov 2011 - Jan 2012	30733.00	0.31	0.50	0.1	1.3	0.50	39.7	8.0	20.3	16.4	29.0	46.0	Unacceptable	2	Acceptable	3
	Aug 2008-Oct 2008	2400000	24.00	3.87	0.1	0.5	17.33	55.8	7.3	244.2	38.7	40.5	53.5	Bad	0	Good	4
	Nov 2008-Jan 2009	2092000	20.92	3.30	0.1	0.5	12.88	50.2	7.3	270.0	30.3	37.2	57.4	Bad	0	Unacceptable	2
	Feb 2009-Apr 2009	2316667	23.17	1.73	0.2	1.9	7.82	49.0	7.3	185.0	28.5	36.0	42.7	Bad	0	Unacceptable	2
	May 2009-Jul 2009	1900000	19.00	2.30	0.1	0.5	6.30	50.0	7.4	180.0	32.0	40.0	56.0	Bad	0	Unacceptable	2
	Aug 2009-Oct 2009	1973333	19.73	2.30	0.2	0.5	8.56	49.5	7.4	216.7	28.9	31.3	32.3	Bad	0	Unacceptable	2
	Nov 2009-Jan 2010	2400000	24.00	2.83	0.1	0.5	13.33	46.7	7.4	121.7	36.0	33.7	37.7	Bad	0	Unacceptable	2
Upper Jukskei, cnr 4th St/ 5th Ave, Bev Valley	Feb 2010-Apr 2010	2400000	24.00	1.27	0.4	1.6	5.23	45.0	7.3	58.7	15.5	36.3	45.7	Bad	0	Unacceptable	2
	May 2010-Jul 2010	1413333	14.13	1.73	0.1	0.5	10.70	45.3	7.3	154.7	8.9	38.0	41.7	Bad	0	Good	4
	Aug 2010 - Oct 2010	760000	7.60	0.86	0.7	0.8	7.35	45.5	7.4	145.0	25.5	38.5	38.5	Bad	0	Acceptable	3
	Nov 2010-Jan 2011	1743333	17.43	0.6	0.3	5.3	2.17	42.7	7.3	73.0	6.6	33.7	38.3	Bad	0	Good	4
	Feb 2011 -Apr 2011	2400000	24.00	0.6	2.2	9.3	0.50	46.0	7.2	58.5	6.8	34.0	42.5	Bad	0	Acceptable	3
	May 2011 -Jul 2011	860000	8.60	0.70	0.1	5.9	0.50	47.7	7.1	96.0	7.0	35.7	28.2	Bad	0	Acceptable	3
	Aug 2011 - Oct 2011	1700000	17.00	0.72	0.4	4.10	7.5	46.7	7.5	113.7	12.1	34.7	31.3	Unacceptable	2	Unacceptable	2
	Nov 2011 - Jan 2012	1316667	13.17	0.6	0.7	2.8	4.10	46.0	7.5	88.7	4.5	34.3	30.7	Unacceptable	2	Unacceptable	2
	Aug 2008-Oct 2008	268398	2.68	0.82	0.1	3.5	4.13	32.2	7.7	25.3	1.8	32.5	20.2	Bad	0	Acceptable	3
	Nov 2008-Jan 2009	9298	0.09	0.5	0.1	3.0	0.50	26.8	8.1	21.0	14.4	23.6	18.2	Unacceptable	2	Acceptable	3
	Feb 2009-Apr 2009	45700	0.46	0.65	0.2	3.7	2.08	28.7	7.5	27.8	7.3	27.2	23.5	Unacceptable	2	Acceptable	3
	May 2009-Jul 2009	2800	0.03	0.5	0.1	5.8	0.50	31.0	7.8	14.0	1.1	34.0	25.0	Unacceptable	2	Good	4
	Aug 2009-Oct 2009	8797	0.09	0.92	0.2	3.0	2.42	32.0	7.6	48.8	10.7	30.2	23.7	Unacceptable	2	Acceptable	3
	Nov 2009-Jan 2010	3467	0.03	0.5	0.1	3.8	0.50	29.7	7.6	19.0	10.6	25.0	26.7	Unacceptable	2	Acceptable	3
Cyrildene stream before confluence w ith Jukskei	Feb 2010-Apr 2010	1453	0.01	0.5	0.1	8.0	0.50	36.7	7.6	25.7	5.1	36.0	53.0	Acceptable	3	Acceptable	3
	May 2010-Jul 2010	1107	0.01	0.5	0.1	7.2	0.50	31.0	7.7	12.3	2.5	34.7	28.7	Good	4	Acceptable	3
	Aug 2010 - Oct 2010	240	0.00	0.5	0.1	4.5	0.50	29.0	7.8	28.0	1.3	41.7	17.0	Good	4	Acceptable	3
	Nov 2010-Jan 2011	67580	0.68	0.5	0.2	4.6	0.80	34.0	7.6	20.7	17.9	30.7	30.3	Bad	0	Acceptable	3
	Feb 2011 -Apr 2011	1833	0.02	0.5	0.1	8.4	0.50	37.5	7.5	18.8	2.0	35.0	55.0	Acceptable	3	Good	4
	May 2011 -Jul 2011	1970	0.02	0.61	0.2	8.1	0.60	35.7	7.7	16.7	3.9	40.0	27.3	Acceptable	3	Acceptable	3
	Aug 2011 - Oct 2011	333	0.00	0.6	0.1	4.90	0.50	32.3	7.7	28.0	41.4	34.0	20.3	Ideal	5	Acceptable	3
	Nov 2011 - Jan 2012	10023	0.10	0.5	0.2	3.8	1.43	38.7	7.7	30.3	15.6	33.7	36.0	Unacceptable	2	Acceptable	3
	Aug 2008-Oct 2008	1474700	14.75	2.00	0.1	1.5	16.75	51.2	7.5	128.3	19.4	37.2	31.3	Bad	0	Acceptable	3
	Nov 2008-Jan 2009	2400000	24.00	1.54	0.2	1.5	12.78	43.6	7.5	96.0	42.0	32.0	36.8	Bad	0	Unacceptable	2
	Feb 2009-Apr 2009	2100000	21.00	1.25	0.5	2.2	8.88	46.8	7.4	128.3	12.5	33.3	36.7	Bad	0	Unacceptable	2
	May 2009-Jul 2009	120000	1.20	0.5	0.4	5.7	1.50	40.0	7.7	24.0	1.7	35.0	37.0	Bad	0	Acceptable	3
	Aug 2009-Oct 2009	1853333	18.53	1.65	0.1	0.6	10.40	45.3	7.5	134.7	15.6	35.0	27.5	Bad	0	Unacceptable	2
	Nov 2009-Jan 2010	1076667	10.77	1.60	0.1	0.9	7.87	40.3	7.6	41.3	15.3	28.7	37.0	Bad	0	Acceptable	3
Upper Jukskei, Bruma Lake inlet	Feb 2010-Apr 2010	1026667	10.27	0.5	0.8	5.5	3.77	42.0	7.4	25.7	9.9	36.7	41.7	Bad	0	Acceptable	3
	May 2010-Jul 2010	1040000	10.40	0.75	0.7	3.7	8.27	42.3	7.4	53.3	3.7	37.0	38.7	Bad	0	Good	4
	Aug 2010 - Oct 2010	673333	6.73	0.72	0.2	3.4	7.03	42.3	7.4	81.3	8.1	45.3	27.3	Bad	0	Good	4
	Nov 2010-Jan 2011	37367	0.37	0.5	1.2	7.0	0.64	37.0	8.5	27.0	3.8	31.0	29.0	Unacceptable	2	Acceptable	3
	Feb 2011 -Apr 2011	343333	3.43	0.5	5.2	21.4	0.50	46.0	7.4	45.3	2.8	36.5	40.8	Bad	0	Acceptable	3
	May 2011 -Jul 2011	313000	3.13	0.62	0.1	9.5	0.50	44.0	7.4	69.0	3.7	38.0	25.0	Bad	0	Acceptable	3
	Aug 2011 - Oct 2011	693333	6.93	0.61	0.4	4.90	6.7	43.3	7.7	55.7	5.7	33.7	28.0	Unacceptable	2	Unacceptable	2
	Nov 2011 - Jan 2012	213333	2.13	0.5	0.5	4.6	2.18	43.7	7.8	36.7	15.1	34.0	26.7	Unacceptable	2	Acceptable	3
	Aug 2008-Oct 2008	505	0.01	0.80	0.8	3.2	1.37	46.5	7.6	37.0	6.5	36.8	48.3	Good	4	Acceptable	3
	Nov 2008-Jan 2009	43120	0.43	0.5	0.3	1.4	0.89	30.4	7.5	34.8	21.6	21.4	39.4	Unacceptable	2	Acceptable	3
	Feb 2009-Apr 2009	8532	0.09	0.5	0.2	2.3	0.52	47.7	7.6	49.3	14.7	30.8	45.6	Unacceptable	2	Acceptable	3
	May 2009-Jul 2009	12000	0.12	0.5	0.4	1.3	3.30	38.0	7.4	39.0	2.5	32.0	35.0	Unacceptable	2	Acceptable	3
	Aug 2009-Oct 2009	5888	0.06	0.74	0.6	2.5	2.58	46.2	7.7	38.0	6.4	40.5	48.5	Unacceptable	2	Acceptable	3
	Nov 2009-Jan 2010	13367	0.13	0.5	0.3	1.9	0.65	34.0	7.7	20.3	15.0	24.0	43.7	Unacceptable	2	Acceptable	3
Upper Jukskei, Pretoria Rd, Lyndhurst	Feb 2010-Apr 2010	35333	0.35	0.5	0.3	2.1	0.50	39.3	7.6	65.3	15.3	31.7	60.7	Unacceptable	2	Acceptable	3
	May 2010-Jul 2010	6233	0.06	0.5	0.4	3.6	0.61	52.3	7.9	13.7	5.0	47.3	78.0	Unacceptable	2	Acceptable	3
	Aug 2010 - Oct 2010	643	0.01	0.5	0.2	3.1	0.50	49.7	8.1	26.3	5.6	57.7	67.3	Good	4	Acceptable	3
	Nov 2010-Jan 2011	81210	0.81	0.5	0.9	4.3	0.53	41.3	7.8	25.3	11.5	29.0	38.7	Bad	0	Acceptable	3
	Feb 2011 -Apr 2011	55567	0.56	0.5	0.1	3.8	0.50	51.0	7.7	30.8	7.9	38.0	71.0	Bad	0	Acceptable	3
	May 2011 -Jul 2011	2970	0.03	0.50	0.1	4.6	0.50	62.0	7.7	54.0	2.8	39.3	44.7	Unacceptable	2	Acceptable	3
	Aug 2011 - Oct 2011	4570	0.05	0.50	0.2	2.7	0.54	48.7	8.3	28.3	4.7	37.3	63.0	Acceptable	3	Acceptable	3
	Nov 2011 - Jan 2012	17700	0.18	0.50	0.2	1.8	0.51	41.3	7.9	20.3	3.8	29.0	48.7	Unacceptable	2	Acceptable	3

Satellite Images of Municipal Test Sites





Water Table Index Used by CoJ

TABLE 2: CHEMICAL WATER QUALITY INDEX							
The following parameters are measured in order to calculate the WQI.							
Parameter	**Phosphate**	**Nitrate/Nitrite**	**Ammonia**	**Conductivity**	**Turbidity**	**Sulphates**	**COD**
Measured	as P	as N	as N mg/l	mS/m	NTU	as SO4	as O
	mg/l	mg/l				mg/l	mg/l
Index……….	Algal growth potential	Trophic status, AGP	Sewage, AGP anaerobic st.	TDS, inorganic pollution	Particulate matter, erosion, AGP	Mine pollution	Biodegradable pollution
Concentration ranges							
IDEAL	< 0.2	< 6.0	< 0.18	0 to 70	< 1.0	< 200	< 20
GOOD	0.2 to 0.39	6.0 to 9.9	0.18 to 0.39	71 to 150	1.0 to 4.9	200 to 399	20 to 35
ACCEPTABLE	0.4 to 0.49	10 to 14	0.4 to 1.49	151 to 299	5.0 to 7.9	400 to 499	36 to 44
UNACCEPTABLE	0.5 to 0.6	15 to 20	1.5 to 2.6	300 to 450	8.0 to 10	500 to 600	45 to 55
BAD	> 0.6	> 20	> 2.6	. 450	> 10	> 600	> 55
Source of Guideline used							
	Klip Forum	DWAF domestic	Jukskei WQ object	DWAF	DWAF	Klip Forum	Klip Forum

pH : Ideal range 6.5 to 8.5 Bad < 6.5 or > 8.5 Weighting = 5

MICROBILOGICAL

Concentration Range	Index	Description
<130	>85	Ideal
130 – 600	75 – 85	Good
600 – 2000	60 – 75	Acceptable
2000 – 50000	45 – 60	Unacceptable
>50000	<45	Bad